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"Economic Prospects for 1926"

In Response to Many Requests from the Press, Hon. Herbert Hoover, Secretary of Commerce, Made the Following Statement

ANY business forecast must be simply an appraisal of the forces in motion at home and abroad; for and against progress. All signs indicate that if we will temper our optimism with a sprinkling of caution we shall continue our high level of prosperity over 1926.

The United States has produced and consumed more goods in 1925 in proportion to population than ever before in its history. Our standard of living has therefore been the highest in our history and is, of course, the highest in the world. This improvement, however, has been greater in the urban centers than in agricultural communities.

The dominant favorable factor in our outlook is our increased productivity, due to fundamental and continuing forces—such as the cumulation of education, the advancement of science, skill, and elimination of waste. Other favorable indications on the immediate horizon are that the stocks of commodities are moderate: there is employment for practically everyone; real wages are at a high level; savings are the largest in history and capital is therefore abundant; and the whole machinery of production and distribution is operating at a higher degree of efficiency than ever before. While wholesale prices for the year as a whole have averaged about 6% higher than for the previous year it is largely due to needed advance in prices of agricultural products.

Caution Is Necessary

There are some phases of the situation which require caution. Continuation of real estate and stock speculation and its possible extension into commodities with inevitable inflation; the over-extension of installment buying; the extortion by foreign government-fostered monopolies dominating our raw material imports; the continued economic instability of certain foreign countries; the lag in recovery of certain major agricultural products; the instability of the coal industry; the uncertainties of some important labor relationships—all these are matters of concern. But, as said above, with caution we should continue a prosperous year over 1926.

Agriculture

Agriculture, while it is better than it was two years ago, still leaves the farmers with much accumulated debt, and generally has not gained a stability that makes for contentment because its basic economic problem of market is unsolved. Also it suffers from continued distortion in price relationship of the middle west to the competing foreign countries because our transportation costs to seaboard have had to be increased more than those of its foreign competitors. The projected enlarged program of improvement in waterways is of great importance in this matter.

Construction Industries

The construction industries have played a very large part in the high business activity of the past three years. The volume of construction has been unprecedented during the past year with consequent great activity in the construction-material industries, iron, steel, lumber, cement, etc. Contrary to normal expectations this increased demand has not increased prices, for there has been a slight reduction in building costs due in a large measure to the gradual lengthening of the building season. The increasing Federal, state, and municipal public works programs for next year together with the promise of large electrical and railway extension and improvement, indicate a continuing demand for heavy construction. While it might be thought that the war deficiency in housing has been overcome, yet the high real wage in industry creates a demand for better housing and this condition, combined with the migration to suburbs due to the motor, promises to continue as long as employment remains general. We could hardly expect so exceptional a construction activity to repeat itself, but there will be a large volume in any event.

Transportation

In transportation, our railways are giving the best service in our history and are recovering in average earnings to near the Interstate Commerce Commission standard of earnings of five and three-fourths per cent. There is some improvement from the acute depression in the shipping world; and progress has been made in plans for internal waterway improvement. The electrification of the country has made further great strides during the year toward central generation and interconnection. There has been some pyramiding of power holding companies, much criticized within the electrical industry itself, but the solid progress of the industry is marked by the extension of use of electricity with all its economies in production of goods and saving of labor. Furthermore, taking the country as a whole, there has been a reduction in rates for power and light indicating that the public is securing benefits from the economies introduced in production of electricity.

Foreign Trade

Our foreign trade in 1925 has been exceptionally satisfactory. Both exports and imports have risen materially, the former reflecting an increase in agricultural exports and the latter reflecting the large demand for foreign raw materials and tropical foodstuffs. Exports will total around $4,900,000,000, or about 7% more than in 1924. Imports will amount to about $4,200,000,000 or approximately 17% more than in 1924. Roughly, one-half of this increase in both exports and imports is attributable to greater quantities exported, and the remainder to advance in prices. The major explanation of our favorable trade balance is, of course, to be found in the continued heavy investment of American capital abroad; in essence we are lending foreigners the where-with-all to buy goods from us, or are sending goods to convey our investments abroad. It is probable that the final figures will show that this country has added more than a billion dollars to its foreign investments during the year.

The most remarkable thing about the foreign trade of the United States is that after making allowance for the higher level of prices, both exports and imports are much greater than before the war, in contrast with the quantitative decrease in the trade of the other countries engaged in the war. According to British calculations the exports of that country were in physical volume nearly 25% less in 1925 than before the war, and Germany's exports have fallen off still more. British imports are practically at their pre-war level, and those of Germany materially below it.

Finance

In finance, the year has been characterized by increased savings, comparatively easy money conditions, the issuance of a large volume of both domestic and foreign securities, and by an extraordinary rise in the prices of stocks accompanied by marked speculation on the New York Stock Exchange. This fever of speculation is also wide-spread in real estate and unless our financial policies are guided with courage and wisdom, this speculation may yet reflect into the commodity markets, thereby reversing the cautious buying policies of recent years. Psychology plays a large part in business movements and over-optimism can only land us on the shores of over-depression. Not since 1920 have we required a better informed or more capable administration of credit facilities than now, if we are to continue an uninterrupted high plane of prosperity. In any event there should be no abatement of caution in the placing of forward orders, particularly in view of the great increase in sales of a great variety of merchandise on the installment basis.

In the foreign field as a whole the situation is more promising than at any other time in twelve years. Each year one nation after another abroad gains in economic and fiscal stability, in production and in employment. War-inherited famines have disappeared from the earth, standards of living are everywhere higher than at any time since the war. In fact no one in 1919 would have believed that so great a measure of recovery would be attained in Europe by 1925—a proof of a high quality in European statesmanship. The Locarno Agreement promises much greater political stability, and paves the way for another stage of disarmament with consequent improvement in the economic outlook. Of the disturbed areas England and Germany have not recovered employment in full; France shows economic strength among her people, but popular resistance has so far made it impossible to stabilize the fiscal system; China continues in the throes of civil war, but business nevertheless continues; Russia makes progress as the government slowly abandons socialism. The quantity of goods moving in international trade as a whole has recovered to the pre-war level, although some countries are below, and fully 90% of international business is now based upon stabilized currencies.

On the whole, both our own country and the rest of the world face a more favorable outlook at this turn of the year than for a long time past. We, ourselves, however, need to be on our guard against reckless optimism. What we need is an even keel in our financial controls, and our growing national efficiency will continue us in increasing prosperity.

The Business Situation

The Cleveland Trust Company

Col. Leonard P. Ayres, Vice-President

THE year 1925 has been a year of business recovery developing into prosperity. Its outstanding features have been the continuation at an increasing pace of the great building boom, a record breaking output of automobiles with unparalleled prosperity for the companies manufacturing them, and a great bull market for stocks. Industrial output has been large, railroad transportation efficient, employment general and wages high. The agricultural sections of the country have fared relatively well. The present prospects are that good business will continue well into 1926, although it seems likely that the peak of this present wave of exceptional prosperity will be reached and passed in the coming year.

The underlying cause of this period of unusually good business is cheap credit, and the most important of the factors responsible for the ample supply of inexpensive credit is our greatly increased stock of money gold. The past four years have been a period of business recovery and readjustment following the great price deflation and business depression that began in 1920, and had their most serious effects on commerce, trade and industry in 1921.

At the beginning of that year the banks of this country were in debt to the Federal Reserve banks in sums mounting far into the thousands of millions. Interest rates were high and times were hard. During all the time that has since elapsed the natural processes of recovery and readjustment have been greatly assisted by enormous imports of gold. During the war and subsequent to it, American money was loaned abroad in truly vast volume, and as a result the sums sent back to this country as interest and repayment have been steadily increasing. Moreover, foreign countries have been compelled since the war to make heavy purchases of our goods, and settlement for these has involved large gold payments.

The gold imports have been received through the big commercial banks, and used by them and their correspondents to pay off their indebtedness to the Reserve Banks, until by the summer of last year the banks of this country were practically out of debt to the Reserve System, and interest rates had declined to very low levels indeed. The result of all this has been the building up in this country of a stock of money gold far beyond our business and banking needs. By skillful management the Federal Reserve System has been able to avoid up to this time any recurrence of commodity price inflation, but there has taken place a great credit expansion.

It is this easy availability of almost unlimited amounts of credit at easy rates that largely explains the continuation of the great building boom, and the accompanying prevalent real estate speculation. The pressure of funds for employment is the moving force behind the spectacular expansion of installment buying. The continued convenience and ease of financing purchases of automobiles by partial payments is in no small measure responsible for this year's prosperity of the motor industry, and it largely rests on the oversupply of loanable funds in banks.

The greatest problem on the horizon for American business is the one created by our excessive supplies of gold and by the prospect that those supplies will tend to increase as the years pass. The immediate prospects for business seem most favorable; those a little further in the future seem somewhat less definitely cheering; but the long term prospects arouse misgivings. It may well be that the more conspicuous business developments of 1925 constitute only the first of a series of waves of speculation based on an overexpanded supply of credit.

Home Building

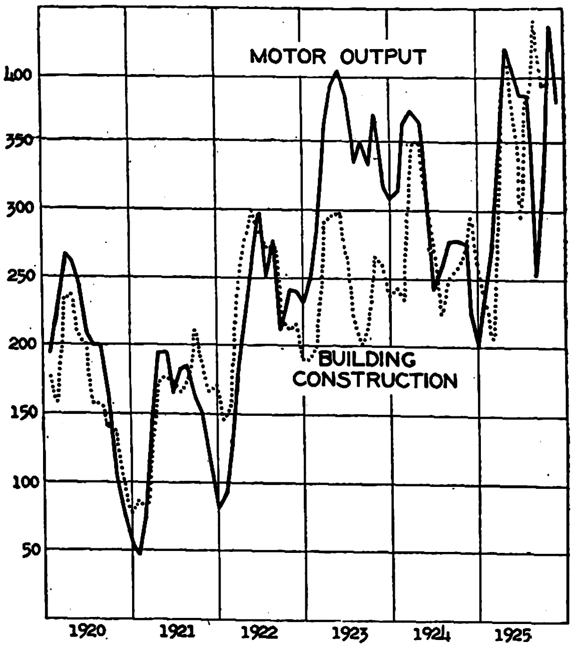
During recent months there has been much discussion as to whether or not the building shortage left by the war and the post-war years had been made up, and new construction was beginning to be overbuilding. Some evidence indicating that it might be has been found in the fact that house rents have been declining for some months in a number of cities.

Further light is shed on the problem by figures recently compiled and published by the Federal Bureau of Labor Statistics. These data show for a large group of cities the number and value of building permits during recent years, and also the number of families provided for by the new construction of houses and tenements. By using the Census estimates of population increase in some 31 of these cities, and also the Census figures for the average size of family in each of them, computations have been made of the approximate numbers of new families added to the population of these cities during 1923, 1924 and the first half of 1925.

These figures for new families have been compared with the data for housing accommodations provided by the new construction during the same two and a half years. In this form the resulting data show how many new family housing accommodations have been provided for each 100 new families in the populations. In every case the new housing is shown to be increasing far more rapidly than the number of new families.

Automobiles and Building

Automobile production and building construction have both surpassed this year all previous records of volume and value. The present period of prosperous business rests in no small degree on the exceptional activity of these two great industries, and their monthly figures are of unusual interest at this time because it seems unlikely that either one can exceed or equal in 1926 the high records established in 1925.



Cleveland Trust Company

In the diagram the two lines show the remarkable parallelism between automobile output and building construction in this country during the past six years. The solid line represents the number of hundreds of thousands of automobiles manufactured each month. The dotted line shows how many million dollars' worth of building contracts were awarded monthly in the 27 northeast states, where the construction represents about three-quarters of that of the entire country. The building value figures do not include the contracts for public works such as bridges, sewers and the like.

In no considerable measure the output of automobiles and the construction of new buildings have had a genuine relationship one to another during these recent years. The building boom that has been under way during the past four years has been largely a boom in the construction of new dwellings, and a large part of the new homes have been built in the suburbs of our cities. Except for the automobile many, if not most, of these new houses would not have been built. If the new allotments and extensions of the suburbs had waited, as they must have in earlier years, for the building of new street car lines, many of them would not have been developed.

Iron and Steel

Important improvement continues in the iron and steel industry. Production and shipments are large, and unfilled orders continue to accumulate. It is becoming less easy to secure immediate deliveries, and buyers are placing orders for their requirements over the first quarter of next year. It is now sure that the production of steel in 1925 will constitute a new high record, while that of pig iron will probably be about 98 per cent of the record high output of 1923. Present indications are that the activities of the industry will be sustained at a high level at least well into 1926.

The growing strength of prices is the notable feature of the market. The averages of iron and steel quotation are now about 49 per cent above the 1913 level. Last summer they were only 42 per cent above. Some seasonal slackening has appeared in the structural steel business, and in the demand from the automobile industry. However, the heavy forward orders in both these lines indicate that much important building is being planned for 1926, and that motor manufacturers are expecting very large outputs next spring.

It now seems probable that railroad buying will increase notably in 1926. Car loadings have been heavier this year than ever before, and earnings greater. The combination of especially hard use of equipment and large earnings available for new purchasing makes it likely that important buying by the railroads is in store.

November brought an increase of 11 in the number of active blast furnaces. At the close of the month 220 furnaces were in blast, out of a total of 385 in the country. This was 57.2 per cent of the total, compared with 54.1 per cent one month before, and a theoretical normal of 60 per cent. A further increase of 11 furnaces will bring blast furnace activity up to its normal line. Since most of the increase in furnace activity occurred during the last half of the month, the increase in pig iron production in November was relatively small. The daily average rate was 100,600 tons, against 97,300 tons in October.

Blast Furnaces and the Stock Market

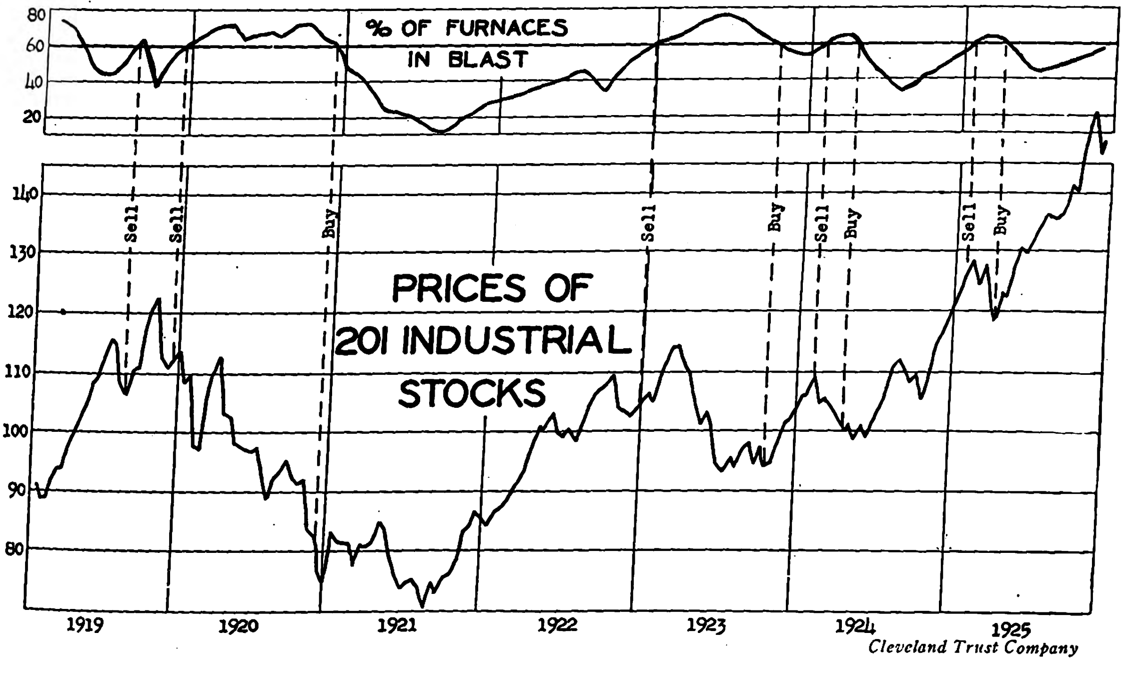
There is a relationship existing between the movements of security prices and the changing percentages of blast furnaces that are active. It has been true over a long series of years that the degree of active production of pig iron by blast furnaces has been a good criterion or indicator of the condition of general business.

The number of blast furnaces in this country that are available for use is something less than 400. For many years past it has remained at about that number, although the smaller and older ones are continually being dismantled and new and larger ones constructed. There is never a time when all these furnaces are in use, even in such periods of high pressure production as the war years of 1916, 1917 and 1918. When general business is very good and industry is increasing, the percentage of furnaces that are active rises to about the 80 per cent level, and when times are bad and business slow the percentage falls to around 40 or even lower.

Over a long period of years it has been true that the average percentage of blast furnace operation, taking good years with bad, has been about 60 per cent. This 60 per cent level has continued to represent about average conditions despite the changing trade practices of the iron and steel industry and despite the increasing size and capacity of the furnaces. A careful study of these percentages over past years, and a comparison with the records of changing prices in the stock market, indicates that when the line showing the percentage of active blast furnaces has been above the average and turns down so as to cross below that level, the prices of stocks are usually at about their low points for that market and soon begin to rise. Moreover, when the blast furnace percentage line has been below the 60 level for some time, and has risen so far in a period of business recovery that it crosses the 60 level on the way up, stock prices are usually near their high points and shortly begin to decline.

In the diagram shown below on this page the lower line shows the changing prices over the past seven years of the 201 industrial common stocks included in the index of the Standard Statistics Company. The upper line shows for the same period the percentage of blast furnace activity. The vertical dashed lines that are drawn down from the points at which the blast furnace line crossed the 60 level show that when the line crossed 60 on the way up stocks were in the selling range of prices, and that when it crossed 60 on the way down they were in the buying range.

At the present time the blast furnace line is rising, but it has not yet reached the 60 level. The industry is expanding its operations, and it is probable that the line will cross the 60 level late in December or early in January. It now seems probable that the coming crossing of that level will again indicate with fair accuracy the time at which most industrial stocks will be in their selling range.



Cleveland Trust Company

From the
Guaranty Trust Company of New York

THE end of 1925 found business as a whole considerably more active than at the close of 1924. The gains in most lines have not been striking, but they have been fairly regular. As in each of the two years preceding, there was a distinct recession in industrial output and in the volume of trade during the spring and summer. The decline was by no means so sharp, however, as that of last year; and, with the substantial recovery of the last few months, nearly all branches of business will be able to report satisfactory results from the year's operations, and to look forward at the beginning of 1926 with the expectation of continuing good business in the immediate future.

The Industrial Situation

Basic industrial output reached its peak in the month of January, 1925, which marked the culmination of the sharp recovery from the depression of 1924. The trend during the first half of this year was distinctly, though not violently, downward. After a temporary recovery in July a new low point for the year was reached in August. This figure was followed by two marked upward movements, bringing the index for October to the highest point recorded since April. Under these conditions it is natural that employment should be large and wages high.

Wholesale and Retail Trade

An encouraging aspect of the situation this year is the fact that large industrial output has been balanced by an active movement of goods through distributive channels. It appears that both wholesale and retail trade in many lines will establish new high annual records. Not since the days of the post-war price inflation have sales of consumers' goods been so large as this year.

Such general business indices as loadings of railway freight cars and payments by check, as well as the more direct evidence of sales by wholesale and retail dealers agree in pointing to a record-breaking volume of general trade.

The total amount of payments by check, as evidenced by debits to individual accounts by banks reporting weekly to the Federal Reserve Board, have run consistently above last year's totals. In the first eleven months of 1925 debits by banks outside of New York City were 12 per cent larger than a year ago.

A large volume of retail trade is clearly indicated by sales of department stores and mail-order houses. Sales of 359 department stores throughout the country were about 4 per cent larger in the first ten months of 1925 than in the corresponding period of 1924. A similar comparison shows a gain of 15 per cent in sales of the two leading mail order houses, which are more largely dependent than retail establishments in general upon farmers' purchasing power.

Well-Balanced Commodity Markets

It is clear from these and other indications of the activity of distribution that the general tendency in 1925 has been for goods to move rapidly into consumption and not to accumulate in the hands of manufacturers or dealers. This is perfectly natural in view of the high level of purchasing power enjoyed by nearly all groups of consumers as a result of active industrial operations, with large employment, high wages and generally adequate margins of profit.

Such a situation provides firm ground for the anticipation of continued high levels of industrial and commercial activity in the early part, at least, of the new year. General conditions in the commodity markets justify an optimistic attitude as a year ago. And the marked improvement in some of the basic industries which have only recently emerged from depression is an additional source of confidence.

Indeed some students of the situation express the thought that present conditions are so good generally speaking that it is not reasonable to expect their unbroken continuance and have the feeling that security values based on this high level of business cannot be maintained indefinitely. Factors offsetting this view are cited by others, such as the fundamental soundness of business and banking conditions and the favorable economic position which this country occupies, as presenting assurance for the continuance of commodity and security markets at or near present levels, at least for the early part of 1926.

It is only in a few directions that a tendency toward over-expansion has appeared, rendering the situation as a whole perhaps less reassuring than that which prevailed at the end of last year. These possible sources of danger represent a certain relexation in some lines in the conservative attitude which has characterized the policies of business men in recent years. As long as the present abnormal situation in international finance persists, the maintenance of this conservative attitude will be essential to orderly progress.

Items of Interest

NATIONAL INDUSTRIAL CONFERENCE BOARD, INC.

Cost of Government Employees

During 1925 approximately every ten persons engaged or employed in private enterprise in the United States were supporting, on the average, one person depending for his or her living on public funds. This estimate includes public charges in almshouses, charitable and penal institutions and pensioners as well as public employees.

The number of persons in public service, including federal, state and local government employees, since 1923 has increased again, after the decline from the war-time peak, to a total of approximately 2,800,000. This is an increase of about 60 per cent over the number of public servants in 1913, the year before the war.

The direct cost of the service rendered by these public employees and officials for 1925 shows an increase of about 23 per cent over the cost of the 1923 public payroll.

Adding to this the cost of pensions, annuities and allowances paid to war veterans and superannuated employees, numbering approximately 900,000 persons, and the cost of supporting about 500,000 public charges in almshouses and in charitable, correctional and penal institutions, the Conference Board research staff estimates the total cost of those depending for their livelihood directly on public funds during the current year at about $5,140,000,000.

This sum represents about 8.1 per cent of the total national income of 1924, 46.8 per cent of the amount paid out in wages, or 37 per cent of the amount paid out in wages and salaries combined, by all the manufacturing establishments in the country during the year 1923, the latest for which such data are available.

The total public payroll, including the support of public charges, if the burden were distributed equally among persons gainfully occupied but not holding public jobs, would cost each person in private employment, or engaged in business or in a profession, about $125 annually. The corresponding burden on each man, woman or child in the United States would amount to $46 per annum.

Trade Associations

A warning to trade associations not to expect too much from the effect of the recent U. S. Supreme Court decisions in the Maplewood Flooring and the Cement cases, is sounded by the National Industrial Conference Board, 247 Park Avenue, New York, in a specially prepared monograph on "The Scope of Trade Association Activities in the Light of Recent Decisions of the U. S. Supreme Court."

The Supreme court opinions handed down last July have neither overruled nor modified the rulings in the Hardwood Lumber case in 1921, or the Linseed Oil case in 1923, according to the Conference Board's analysis of the significance of the two recent decisions and their bearing on the regulation of trade association practices. But they have clarified the law and have established that there is ample opportunity for mutual co-operation among business competitors in gathering and distributing current information by means of which trade conditions may be improved and stabilized.

However, "trade associations should be careful in their use of the new freedom," and "the use of persistent propaganda and exertion of group pressure to secure conformity to uniform policies might still be regarded by the courts as evidence of unlawful conspiracy." Agreements or understandings, express or implied, as to prices or production should be avoided. Stress is laid on the fact that data exchanged between competing concerns, particularly such as refer to sales and prices, should deal with past and closed transactions only. But this the Board believes, would not preclude the analysis of general current business conditions and price trends by an association.

The Board's treatise interpreting the Maplewood Flooring and Cement decisions is issued as a supplement to its recent report "Trade Associations: Their Economic Significance and Legal Status."

Application of Mechanical Force Big Factor in America's Economical Superiority

The rapid and vast increase in the use of mechanical power is the secret of the high productiveness and efficiency of American industry, agriculture and transportation, and is one of the factors accounting for the high "real" wages, or prosperity, of the American worker, according to comparative studies of the development of primary power in the United States.

Primary power available in manufacturing industries, mining, agriculture and on the railroads today exceeds 150,000,000 horsepower. Of this, nearly one-fifth, or about 33,000,000 horsepower is available in the manufacturing industries, as against 2,346,142 horsepower in 1869, the earliest date covered by the study.

Brainwork vs. Brawn

The significance of this immense growth of power development, an increase of 1,311% or 14 times the amount of power application in about 50 years, is not merely that of correspondingly greater production, but brings with it additional benefits to the individual worker as well as to industry as a whole, and to society at large. For, to the extent that mechanical power is harnessed to do the heavy work in industry and the purely physical things that machines can do, formerly done by human labor, to that extent men are released from purely physical work for the doing of things that require brainwork. While the earning power of brawn is limited to so many dollars a day, the earning power of brainwork is limited practically only by the ability of the individual. Furthermore, inasmuch as power application makes possible greater production at lower unit cost, the effectiveness of the individual worker, and with it, that of the entire industrial enterprise is increased, permitting of greater earnings both for the investors as well as the workers in industry.

Since 1899, or during the last quarter of a century, installed primary power in manufacturing industries increased 236%, while the number of wage earners increased only 90%, and the volume of production 185%. While data concerning the "real" wage, that is the purchasing power of workers' earnings as far back as 1899 are lacking, the purchasing power of average weekly earnings in the United States today is 28% greater than it was in 1914. Although at the beginning of the century there were only 2.14 horsepower behind each worker in industry, in 1923 the horsepower per wage earner was 3.33, an increase of 56%. The total primary power available in manufacturing industries in 1923 was 33,094,228, of which slightly more than 50% was steam power and about 40% was electric motor power run on purchased current. The rapid increase in the use of electrical power is shown by the fact that whereas in 1889 less than one-half of one per cent of the installed power in manufacturing industries consisted of electric motors, run by either purchased or generated current, in 1923 67% or more than two-thirds of the total primary power was represented by electric motors run by purchased or generated current.

Power Used on Farms

The use of power in American agriculture has had a similarly remarkable growth and has had similar effects in increasing the productive efficiency of labor. It is estimated that agriculture in the United States uses practically as much primary power as all manufacturing and central station plants combined. In 1850, there were less than two horsepower per worker engaged in agriculture, while by 1920 the number of horsepower per agricultural worker had more than doubled, reaching 4.5. In this way the volume of production per worker in agriculture has been nearly trebled in the past seventy-five years. The horsepower available on American farms in 1850 is estimated at less than 8 million, but had increased to over 47 millions by 1924. Through this vast increase in power, it is estimated that nearly 20 million less persons are required for agricultural production in the United States today than would have been needed if this great growth in power had not taken place. Whereas in manufacturing industries more than two-thirds of the power used is electrical, in agriculture as yet only a small percentage is of this character. In 1924 less than 5% of the total horsepower available in agriculture was electrical, while over 40% was derived from work animals.

Since the power used and the capital investment through which it is applied, are important factors in the productivity of labor, it is significant that the investment per primary horsepower is largest in agriculture, approximating $1,800 per horsepower, followed by manufacturing with about $1,500 per horsepower, mining with $1,000 and the railroads with about $300 per primary horsepower.

BUREAU OF MINES, WASHINGTON

Approximately 140,000 workers in the mineral industries have now been trained in mine rescue and first aid methods by employes of the Bureau of Mines, according to the annual report of the Director. The chief purpose of the Bureau's recently organized safety extension service will be to give advanced training in rescue work and bring to the attention of mine officials the latest advances made in the prevention of mine fires and explosions and in the conduct of rescue operations and disasters. The Bureau has also recently begun a campaign for greater safety in the petroleum industry.

Helium, the rare gas used in the giant dirigibles, seems likely to find a new and important use in the conduct of diving and tunneling activities as the result of tests made at the Bureau's Pittsburgh experiment station. When mixed with oxygen, helium forms an atmosphere that is as breathable as normal air, and the tests indicate that the use of helium-oxygen mixtures materially reduces the time of decompression—the process to which divers and men who have worked in compressed air are subjected before they enter outside air. As a consequence the hazard of compressed-air illness, or caisson disease, among tunnel workers and divers can be greatly lessened.

Although most desired as a lifting gas for balloons and airships, helium will undoubtedly find other uses if the cost of production can be lowered. For instance, it can be used instead of nitrogen in electric light bulbs. Practically all the helium now available, however, is recovered from natural gas by the Government plant at Fort Worth, Texas, and is controlled by the Government. Research into the recovery of helium began during the World War, and in this research the chemists of the Bureau of Mines have taken a leading part. At Washington the Bureau has a cryogenic laboratory where experiments relating to the recovery and purification of the gas are carried on.

Methods and equipment by which great savings of fuel can be effected at central power stations, at small boiler plants, on steam locomotives, and in private residences have been called to the attention of the public through the fuel investigations of the Bureau.

In its efforts to conserve the supply of high-grade coals through the use of those of lower grade, the Bureau has shown how lignite can be utilized more efficiently and has demonstrated that low-grade Middle West coals can be used for making city water-gas in place of the more expensive eastern cokes. The Bureau has taken an active part in campaigns to lessen the smoke nuisance in cities, has shown how coal can be burned without the production of dense smoke, and has studied the processes that look to the disuse of raw coal as fuel. The Bureau has also determined the comparative value of different fuels—as coal, wood, and coke—for house-heating boilers and has shown the householder how he can reduce his coal bill.

Enormous economies are theoretically possible in various metallurgical operations by the substitution of oxygen or oxygenated air for ordinary air. With the assistance of an advisory committee the Bureau of Mines is working on the problems involved.

DEPARTMENT OF AGRICULTURE
Washington, D. C.

Excerpts from Annual Report of the Secretary of Agriculture

Federal-Aid Roads

A greater mileage of Federal-aid roads was completed during the fiscal year 1925 than in any previous year. The aggregate length of the project completed was 11,329 miles, and the largest previous year's record was less than 10,000 miles. This addition brings the mileage completed since 1917 up to a total of 46,486.

In addition to this completed mileage, which includes only the projects that are entirely completed, there were under construction at the close of the fiscal year other projects the aggregate length of which was 12,463 miles. A very considerable portion of this mileage is actually completed, but will not be so reported until the projects in which it is included are completed in their entirety.

The total cost of the projects completed during the year was approximately $243,000,000, of which approximately $111,000,000, or more than 45 per cent, was paid by the Federal Government. The cost of the entire mileage completed from 1917 to date has been more than $845,000,000, and the Federal Government has paid of this total approximately $373,000,000.

This total Federal expenditure over the nine-year period has been large enough to make the Federal participation effective without necessitating extravagant expenditures of State funds to meet it. As the Federal excise taxes on motor vehicles, tires, and motor-vehicle accessories have produced since 1918 Federal revenues amounting to $800,000,000, it may be seen that the Federal-aid highway expenditures have been far more than paid by owners of motor vehicles. The same motor-vehicle owners contributed to the State treasuries in license fees and gasoline taxes during the last fiscal year more than sufficient funds to pay the States' share of the cost of the Federal-aid roads in all States with the exception of New Mexico.

In the roads completed during the year all approved types of construction are represented. Gravel roads, of which there were 4,203 miles, constitute the largest single class. The completed mileage of all types was as follows:

	Miles completed
Graded and drained earth roads	2,064
Sand-clay roads	719
Gravel roads	4,203
Water-bound macadam roads	129
Bituminous macadam roads	912
Bituminous concrete roads	341
Portland cement concrete roads	2,807
Brick roads	107
Bridges (over 20 feet in span)	47
Total	11,329

One of the most important projects recently completed is the Wendover cut-off across the Great Salt Lake Desert between Salt Lake City and the Nevada line. The completion of this road brings to a successful conclusion a five-year effort to bridge the obstacle to transcontinental travel which has always been presented by the salt desert. Its construction could not have been undertaken but for the financial assistance offered by the Federal Government; and the flow of interstate travel which has already begun between Salt Lake City and northern and central California is one of the outstanding evidences of the necessity for Federal participation with the States in interstate highway construction.

Rubber Possibilities in the United States

On account of rapidly advancing prices there is an acute demand for information regarding rubber-production possibilities in the United States and in tropical America. It is believed by many industrial and economic writers that a serious shortage in the supplies of crude rubber is impending, in addition to the dangers that have been recognized in being dependent upon the East Indies for a product that within a few years has become indispensable not only for industrial purposes but for military requirements. About three times as much rubber is used in the United States as in all the rest of the world. Rubber is now as essential to agricultural production and marketing of crops as to the urban industries. The present development of our civilization could hardly be maintained without rubber.

Interest in the possibilities of rubber production is intensified by the large areas of unused or partially used land in the United States, especially in the southern and southwestern regions, where rubber production might be feasible if suitable plants were discovered and methods of utilization were devised.

It has been determined already that several of the rubber-producing plants grow well under our conditions and could be utilized, but other species or varieties may be found that yield more or better rubber or are better adapted to cultivation under our conditions.

Investigations of the problems of rubber production are being based on a new principle or method of procedure. Attention is first given to the cultural characters of the plants, so that intensive technological investigations of extraction and utilization methods may be directed to the species that are most readily propagated and that afford the best assurance of production in large quantities. In this way the investigation of agricultural possibilities will not be restricted to the species that have served as commercial sources of rubber, since the agricultural possibilities obviously do not depend upon the abundance of a plant in the wild state or upon the exploitation of its natural products. Some of the most important crop plants are not known in the wild state or exist only in limited numbers under restricted conditions.

Several of the tropical rubber-producing species thrive and appear well adapted to conditions in southern Florida. Although the East Indian plantation system of production apparently would not be feasible in Florida on account of the high cost of labor, it is not impossible that other systems and methods of production and extraction of the rubber may be developed that could be established as regular agricultural industries. Popular interest in such possibilities of tropical development in southern Florida is very acute among the thousands of new settlers who are now establishing themselves in the more tropical districts. Although private co-operation may contribute to earlier solutions of the experimental problems, commercial plantings of rubber can not be considered advisable until practical methods of handling the crop under the Florida conditions have been devised and demonstrated.

Rubber plants that are natives of dry regions are being tested in California. Special attention is being given to one of the native species of milkweed (*Asclepias subulata*), which appears to be the most promising from the standpoint of growing on waste lands and of producing the largest quantity of rubber-bearing material readily and cheaply.

Plantings of all available species of rubber plants are being made in the Canal Zone in co-operation with the experimental garden of the Canal Zone at Summit, near the middle of the Isthmus. By permission of the War Department a tract of 10 acres on the Atlantic side of the Isthmus, at the Fort Sherman Military Reservation has been made available for experimental plantings of rubber. These plantings are on lands that are being drained to control mosquitoes and that afford conditions apparently quite similar to those of the locality where hevea rubber has thrived in Haiti. From seed beds to be established in these or in other suitable places it is expected that seedlings of hevea can be transplanted at least in small numbers to many localities that can be selected to represent the full range of conditions in the Canal Zone and adjacent districts of Panama, to determine the practicability of commercial plantings of rubber or of utilizing waste lands for reserve plantings from which emergency supplies could be drawn.

DEPARTMENT OF COMMERCE WASHINGTON.

Secretary Hoover Favors Arbitration

Describes New Law as Important Step Toward Elimination of Business Waste

Answering inquiries from business men regarding the new Federal Arbitration Act, the passage of which was strongly supported by the Department of Commerce, and became effective on January 1, 1926, Secretary Hoover declared that he believed the act represented an important step toward elimination of business waste.

"The information collected by the Department of Commerce over the past several years clearly shows that the substantial element of the American business public is overwhelmingly in favor of arbitration in the settlement of commercial disputes in both domestic and foreign trade. In addition it has the approval and support of leading members of the bar throughout the United States."

In the field of waste elimination it comprises another important advance, according to the Secretary, and as a result he says that he has "encouraged every reasonable movement in making arbitration accessible to merchants everywhere."

The new law, known as the United States Arbitration Act, was passed at the last session of Congress. By this law, written provisions for arbitration in maritime transactions or in contracts evidencing transactions involving commerce with foreign nations or among the several states, for the first time, are made enforceable in the federal courts. If so contracted, judgment may be entered on the awards of arbitrators by simple procedure. Awards may be vacated by the courts only if procured by improper means, if the arbitrators were guilty of misconduct or if they exceeded or improperly executed their powers in material manner.

To aid business men interested in arbitration the Department of Commerce through its Division of Commercial Laws will endeavor to furnish information within the scope of its activities concerning operation under the Federal law and the arbitration of international commercial disputes. It will also provide means through which trade bodies and groups interested in arbitration may be put into communication.

"Research and Engineering"*

By E. B. CRAFT,
Executive Vice-President, Bell Telephone Laboratories

THE subject of RESEARCH is so broad—Engineering is so broad, that it is difficult to choose an angle from which to approach it. Our experience during the World War brought very much to the fore this question of industrial research, in fact, all kinds of research, and we realized then, probably as never before, what an important factor it was and might become in our national economy.

Since the War the subject has been very much in mind and various agencies have been established for promoting research and carrying it on.

Other countries — England particularly—have given great attention to the question of industrial research and have set up national agencies for its conduct.

In spite of the great amount of talk on Research, there seems to be a very vague idea in the minds of men as to what Research really means. Some people think that research means working with test tubes and microscopes in the laboratory. Others think that confining oneself to almost any subject intensively is research. Webster says that Research means "Diligent inquiry; careful or critical examination in seeking facts or principles." He also says that Engineering means "The science and art of utilizing natural laws and materials." So you see it is very difficult to draw the line between Research and Engineering. They have an obvious relationship, and it is not to be wondered at that there seems to be a very indefinite idea in the minds of many as to just what Research is; where it ends and where Engineering starts.

We do know, however, that the advances in our civilization throughout the centuries have been almost wholly due to the researches of brilliant scientists and workers who, in spite of misunderstanding and ofttimes oppression, have, through their own individual efforts, established one by one the milestones which have guided humanity on its way.

Research in Industry

The idea of applying these methods of systematic and logical deductions to our every-day industrial and technical problems is, however, of comparatively recent origin. Many of our industries of today had their beginning in the work of individuals of a research mind. A single idea, ofttimes born of an inquiring turn of mind, has formed the basis of an entirely new industry which has added greatly to the world's wealth and happiness. By the same token the continued success of many of these industries has to a large degree depended upon the efforts that have been made to continue research in the conduct of their affairs.

As these industries of ours have grown, both in size and the scope of their activities, we have found that the supply of these outstanding geniuses is wholly inadequate, and we have been forced to devise some way out of this difficulty.

Along with this growth of each industry the technique has become so involved and specialized that we have reached the point where we have exceeded the capacity of the individual mind to cope with all its complexes.

Specialization has therefore been brought to the point where a man's whole life may profitably be devoted to one particular phase of the business. This same specialization is extending to all branches, and, as a result, we have been forced to evolve a mechanism whereby the activities of groups of these specialized workers may be properly co-ordinated and directed. This new mechanism may be termed "organized research" and is one of the important developments of the past ten to fifteen years. Another way to express it is the group as distinguished from the individual method.

Now, organized research does not necessarily mean large numbers and elaborate equipment. These factors may be adjusted to fit the problem in hand. What it does mean, however, is trained minds, properly organized and directed, to seek for the truth and facts underlying the problem in hand—whether it be the development of a new tool steel, a longer wearing fabric or even a more prolific fruit tree.

At the same time, these trained minds must be in a state which will permit of the subordination of the individual to the accomplishment of the ultimate result; the job itself being the ultimate aim rather than the immediate return to the individual. This incidentally, has been one of the most difficult problems to work out in connection with the establishment of organized research—to convince the worker that his own welfare and advancement can be adequately cared for in this system of group working.

Individuals do not live long enough nowadays to accomplish a great deal by themselves, and it is certainly a tremendous incentive to the individual, in connection with research work, to be associated with an organization of such dimensions and capacity that real results are accomplished within a short period of time. He is not only permitted to work on his own job and see it finished, but many jobs—at least many more than he otherwise could, were he going it alone.

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*Address before the Engineers Club, Philadelphia, Oct. 20, 1925.

Example of Organized Research

I am going to describe to you an example of organized research, and you will have to pardon me if I speak of the firm with which I am connected, because it is the one I know most about and therefore can speak with greater knowledge.

The telephone was born in a research laboratory fifty years ago; that research laboratory was the workshop of Dr. Alexander Graham Bell, in Boston.

Research has been and is the foundation of the telephone communication industry, and the original laboratory of Bell in Boston has now grown to the dimensions of 3,500 to 3,600 employees and half a million square feet of space and a $6,000,000 plant, devoted entirely to the carrying on of research and development in connection with the electrical communication industry.

This organization of 3,600 persons must necessarily be made up of specialists, and there must be a mechanism whereby their activities may be properly co-ordinated. There are physicists, chemists, metallurgists, mechanics—all sorts of technical experts associated together to work on a common problem. Their own operations are concentrated in groups, each one of which has the facilities and necessities to carry on its particular part of the work. The problem itself is solved from the standpoint of the group as a whole; each one contributes that part which he is best fitted to contribute and the efforts of all are united to obtain the answer to the main problem.

It has taken many years to establish the idea in the minds of these individuals—these specialists, that they really could do their best work in such a scheme of operation. You know research is a highly individual process. I do not know of anything that is much more individualistic than the creative process. It has therefore been a difficult task to bring about the state of mind of which I have spoken, which makes them really believe that their own interests, and the interests of the work as well, are best served by subordinating their own personality to the extent that is necessary in carrying it through.

I am going to give a few illustrations of various types of work which will serve to give you a picture of the broad ramifications in research activity to serve the telephone industry.

Radio and Wire Telephony

Radio is very much in the minds of everyone these days. I wonder if many of you realize that the vacuum tube, which is the very heart of radio as you see it in your receiving set, was developed for an entirely different purpose. The vacuum tube as now employed in radio broadcasting was developed for use as an amplifier or a "repeater," as it was called then, to provide long distance telephony over wires. It was just prior to the War in 1914 that this vacuum tube was perfected for this particular purpose. As a matter of fact, it was not until 1914 that it was possible to talk by telephone across the continent. Not only was the vacuum tube, which is now the basis of a great deal of radio equipment, developed a long time ago, but nearly all the elements that go to make up the modern radio broadcasting equipment are elements which were developed for use in connection with wire telephony. As a matter of fact, wire telephony and radio telephony are practically identical. The only difference is that in one case you are using a wire for the conducting medium, while in the other case space is the conducting medium.

As I have said, it was not until 1914 that it was possible to talk across the continent. The vacuum tube used as an audion—an audio frequency amplifier, loading coils and other instrumentalities—have removed most of the difficulties of long distance communication over wires. The only limitations that are now imposed are geographical and physical, because it is now possible to talk to any place to which wires can be strung. I just mention this to give you a little side-light on this radio business.

Telephotography

Quite a different type of thing has been the recent development in telephotography, about which you probably have seen a great deal in the papers. The Laboratories were asked about a year and a half ago to get together telephotographic equipment as quickly as possible in order that we might demonstrate the commercial possibilities of transmitting photographs by wire over the telephone system. Six weeks after this request was made photographs were transmitted over the telephone wire from New York to Yama Farms, N. Y., and these photographs were of such a quality that an expert would be required to detect the difference between the transmitted photograph and the original. It is now possible to transmit a 5" x 7" photograph over practically any distance of line—New York to San Francisco, for instance—in seven minutes and it really does take an expert examination to detect the difference between the original picture and the one that is received. This was not just luck, and there is nothing very remarkable about it, either. The particular problem was analyzed into its elements. We had the photographic problem. We had the matter of transmitting the signals over the line. We had the matter of producing synchronous rotating mechanisms at the transmitting and receiving ends. We had the matter of setting up a photo-electric cell system for transmitting signals through the action of light thrown upon it.

What we did was to assign these various elements of the problem to the particular specialists who knew the most about them. Each one of these specialists applied his knowledge and experience to his own particular part of the problem, and within six weeks time they were transmitting photographs.

This is an example of organized research and I am mentioning it because it illustrates beautifully the manner in which present day research work can be carried on by an organization devised for the purpose. Photographs, of course, have been transmitted experimentally by wire by various workers in the last ten to fifteen years, but none of them has been entirely successful.

Ocean Telegraphy

Another quite different type of research which has its interesting points is that which has recently taken place in connection with high speed ocean telegraphy. You have all heard of the new cable that was laid between New York and the Azores by the Western Union Telegraph Company. This cable in outward appearance and in dimensions is practically no different from the cables that have been laid in the last fifty years. It has one essential difference, however, in that messages can be transmitted over this new cable using the same size copper conductor, with about five times the speed possible in the old type of cable. This is accomplished by the application of an old idea—the process of loading the conductor in a manner very similar to that employed in telephone wires on land, where lump inductances were introduced to improve the characteristics of the line and reduce attenuation.

Now it is perfectly absurd to consider placing loading coils in a cable which must be laid at the bottom of the ocean. Everyone knew the ideal way would be to wrap magnetic material around this wire. Unfortunately, however, there was no magnetic material that came anywhere near meeting the requirements. You see the problem was largely one of obtaining a new material in this case. The result was the discovery of an entirely new magnetic material to which the name "Permalloy" has been given—an alloy of nickel and iron, which, when treated properly by heat, possesses perfectly remarkable magnetic properties. For instance, if you take a rod, say, ⅛ inch in diameter, and lay it in the axis of the earth's magnetic field, it becomes magnetically saturated. That same rod will measure one dimension when pointing north and south and another when pointing east and west. By wrapping a tape of this new material around the conductor of submarine cable the problem is solved and the result is that we can now do with one cable what it took five cables to accomplish before. This is another example of organized research of a little different character.

Speech and Hearing

Another branch of the work which has a particularly scientific interest is that relating to the fundamental thing with which we are dealing in connection with telephonic communication—speech and hearing. A telephone conversation is carried on not only through a telephone transmitter at one end of the line and a receiver at the other, but the organs of speech of the speaker and the organs of hearing of the listener, and it would be pretty poor engineering to design the instruments without regard to these organs. Strange as it may seem, however, that is just exactly what we did, and we learned about speech *after* the telephone had been developed. Nevertheless, by learning more about the fundamentals of speech and hearing it has been possible to do more with the telephone. Perfectly remarkable facts have been disclosed with regard to the hearing process—facts that were unknown to the physiologist and the otologist. They did not know about these fundamental things which research has disclosed.

An interesting by-product of this work has been that as a result of these really fundamental studies there has been devised a measuring device for which we have been searching many years.

In order to do any research in hearing you have to know how to measure hearing, and the first thing was to develop a measuring device. Such a device has been successfully worked out so that now the otologist can measure both quantitatively and qualitatively the acuteness of hearing of his patients. It is a method which can be duplicated, putting for the first time the treatment of deafness on a really accurate basis.

Artificial Speech

Another example about which probably some of you have heard, but I am going to mention it just the same, has to do with speech. There are a great many people, I imagine, who really do not know what the machinery of our speech organs is. There are a lot of people who think they talk with their vocal cords, for instance. Of course, we do not. All the vocal cords do is to produce the audible tones. Articulation, the thing which converts sound into speech, is produced through the use of the tongue, the lips and the main cavities of the mouth.

About a year ago we were approached by an eminent surgeon who had developed a technique for the cure of cancer of the throat. This technique was very successful in that it cured the patients, but unfortunately, left them mute. He thought it would be a wonderful thing to give these people their voices back and he came to us. He said: "It seems that you ought to be able to do this, if anybody can." We said we would try it. Shortly after his visit we turned over to him an artificial larynx by which these mutes were able to speak with ease. It consists of nothing more or less than a little rubber squawker properly enclosed with an air inlet and outlet. The air from this squawker is led through a tube similar to a pipestem which is placed between the lips of the mouth. Air is supplied through an opening in the windpipe resulting from the operation. By forcing air from the lungs through the device a tone is produced. Through the proper moving of the lips and tongue this tone is rendered articulate. So it has been made possible for those unfortunates to talk as a result of this work which was carried on for an entirely different purpose. Not only that, but we found some of the doctors' patients who did not have an opening into the windpipe, who breathed through their mouths so there was no place to put this little tin whistle; so they were provided with a bellows under the arm for supplying the necessary wind pressure. By working this bellows back and forth, holding the pipestem in the mouth, they could carry on perfect conversation.

This may sound amusing but it means a great deal to those poor people, who are now able to carry on their daily avocation just as though they were normal human beings.

Phonograph Recording and Reproducing

There is just one more thing I should like to mention which has to do with something that is quite close to you gentlemen in Philadelphia, and that is the work done recently in connection with phonographic reproduction and recording. I am mentioning it here because it brings out another phase of research work which may be somewhat new to some of you. Of course, the phonograph or talking machine has been in existence for a long time. By the way, it was originally invented by telephone men—Mr. Edison and Mr. Berliner—who were telephone workers way back in the old days of 1878 and '80. The phonograph was arrived at by the old empirical method of cut and try and while it met with popular favor, there came a time in the evolution of things when the phonograph as it then was, was not sufficient. Other things—new things, had come in to show what could be done in the way of reproduction of music and speech, such as radio broadcasting, which made it evident that something more could be done than was possible with the present form of phonograph. It was only natural, therefore, that an attempt should be made to apply the results of research in the communication field to this problem. Electrical methods which were developed for use in the public address system—loud speaking telephones and the methods and equipment devised for use in the transmitting end of radio broadcasting—were put to work to give us a new and improved method of making phonograph records. With this new method the old limitations surrounding the recording of musical sounds and speech are removed, and it is now possible to record anything that the ear can hear.

In the matter of reproduction, however, we have quite a different problem. Here we have a purely mechanical problem; there is nothing electrical about it. What we are trying to do is to translate mechanical energy delivered to the needle of the phonograph into sound in the air—a straightforward mechanical proposition—and it was solved, strange as it may seem, by electrical methods. Equations which had been set up for calculating the characteristics of high frequency electrical circuits—loaded telephone lines—were used to calculate the mechanical elements of the system. The mass, stiffness and elasticity of the various elements going to make up the moving system, the shape and dimensions of the horn with its air column out into the open air are all factors which had to be taken into account in the solution of the equation, and the result is what might be termed a loaded mechanical line designed to transmit wave motion. With this system it is possible to convert mechanical wave energy into sound with practically no distortion over a range of from 100 to 4,000 or 5,000 cycles. The limits heretofore have been roughly 350 to 3,000. By applying the methods which had been developed by research in the communication field it was possible to solve the problem of the proper sort of reproduction for phonographic purposes.

I mention this as another example of the wide application of almost any sort of worth while research.

General Discussion

I have dwelt somewhat on these examples to serve as a background to bring out some other points I have had in mind. Many of our industries in this country have established great research organizations and are doing tremendously valuable work and are receiving all the support necessary to their proper operation. They are organized.

But, to make research industrially effective, we have to do something beside organizing research. It is not enough to build a beautiful building and put a few scientists in it and tell them to go to work. In order to make industrial research effective it has to be considered as an integral part of a complete industrial organization. I am sure that many of the failures and disappointing results that have been obtained in the establishment of research organizations in industry have been due to the fact that this important factor has been neglected—that is, that unless the research organization is a working unit of the complete industrial aggregation and properly co-ordinated with it in all its angles we are not going to obtain satisfactory results.

Now, by their very definitions, Research and Engineering are related and one, of course, cannot get along without the other. It is a popular idea, however, that Research is sort of "high-brow," and the real practical part of the business, such as manufacturing, engineering and sales must look with a rather skeptical eye at the product of these "high-brows." It is only natural that this has been so and it is usually the scientist's own fault. I want to quote something I saw the other day which I thought interesting in this connection. I had brought to my attention a copy taken from the Wheeler collection in New York of some of the records of the famous patent suit between Morse, inventor of the telegraph, and Joseph Henry. Testimony was taken in the city of Philadelphia in September, 1851, and in the testimony of Joseph Henry, one of the greatest scientists this country has ever produced, we find:

"My whole attention, exclusive of my duties to the college, was devotel to original research, and I left to others what I considered in a scientific point of view of subordinate importance, the application of my discoveries to useful purposes in the arts. Besides this, I partook of the feeling common to men of science, which disinclines them to secure to themselves the advantage of their discoveries by a patent."

Then I note something in the margin, written in Mr. Morse's own handwriting, in which he says:

"He leaves to others to do that which alone makes discoveries of any benefit to the world, and strange to say, would disparage the man who thus attempts to make the scientific discovery beneficial."

So, away back in 1851, there was the same idea prevalent. Fortunately those days have gone by and the present idea is to use both talents in your business. Engineering cannot get along without science, and science would not be supported very long if there was not engineering to make it effective to mankind.

I thought this very interesting as an example of the attitude of mind which has even to this day put its impress on the minds of the uninformed.

Industrial research is a business proposition. It is one of the most practical things in the world. It does not necessarily follow that when scientists are brought in common sense and all commercial sense go out the window. Some of the most practical minded men I have known have been men of scientific training and achievement.

None of us would go so far as to say that the laboratory scientist should be made the head of a Sales Department or vice versa, but unless the Sales Department and the Manufacturing Department and the Engineering Department of your industries do take him into their fold and use him in their business, they may wake up some day and find that their business, about which they were so complacent, has landed on the rocks.

This matter of management is one I cannot overemphasize. By management I mean the proper coordination of research with all the other branches of an industrial enterprise.

In this connection I should like to mention an instance that occurred this last summer. We received a visit from a brilliant young Japanese who is in charge of the Research Department of one of the large Japanese industrial groups. His visit to America was to familiarize himself with the latest methods of conducting industrial research in this country, but I found the question that was uppermost in his mind and about which he was very much concerned had to do with what could be done toward convincing his people that the research organization should be considered as a part of their entire industrial mechanism. His people were apparently alive to the advantages of research and had set up quite an elaborate organization, but that is as far as they had gone. They had not completed the job to the extent of making it a working part of their entire mechanism. This is true of a lot of our people in this country today. They think it is the style to install a research department and having done that they wonder why it is that satisfactory results are not being produced.

We have heard too much talk about selling the idea of Research. We do not have to sell the idea of research nearly so much as to teach the young idea how to shoot—how to do Research.

We all admit that it takes years to establish a commercial enterprise so that it is on a going basis and doing the thing that it was intended to do in the first place. Business men are quite content to work for a good many years before they in a position to pay dividends on their investment, but when they have a problem of a scientific character to solve they think all they have to do is to turn it over to a scientist, who, by waving the magic wand, creates things out of nothing, and, if the answer is not coming forward within six months, then Research as an institution has failed. This is the idea that has to be combated by you engineers; we must persuade business management that there are the same factors entering into the conduct of research problems as in connection with the commercial enterprise and the same limitations are involved in its conduct.

I maintain that Research today is not a luxury but a necessity. For many years we have been very prosperous. We are an industrial nation. We do things in a big way and we do it by organization. A sort of latent or inherent mechanical genius has had a great deal to do in carrying us to the point at which we have arrived.

We all are familiar with the Yankee inventor type. The New England mechanic really established the basis of our country's industry. Times are changing, however, and the methods of the Laboratory are very rapidly replacing the methods of the machine shop, and it behooves us to recognize this fact and to steer our course accordingly.

DISCUSSION

FRANK G. BREYER, of Palmerston, Pa.:

The research organization I represent is a mere child in research as compared with the elder statesman, the A. T. & T. Occasionally, however, "from the mouths of babes cometh wisdom" and there may be a chance pearl in what I have to say.

I represent the Development Department of an organization the individual technology of which was founded, not in the Laboratory, but out on the dump. The most individual work of the New Jersey Zinc Company is the manufacture of zinc oxide by the Wetherill Process. Instead of starting from careful and painstaking laboratory work the fundamental discovery underlying that process was made by a man on the dump, where he saw zinc oxide coming off from a chance mixture of coal and ore thrown on an iron grate by a yard man. That was way back in the 1850's. An operating organization has practiced the art developed from that discovery ever since. We cannot say that there has been no development work going on, because there has. The operations have changed in a normal operating growth fashion; there has been some development work going on, too, but it has never been organized.

In the last ten years there has been a great change, due to another accident—the fact that one of the seeds planted by these electrical men took fruit in our Company—a man formerly with the Western Electric Company—a production man—came to us and became the General Manager of our Company. He had no specific idea as to how to start organized development in a metallurgical industry; he had the belief, however, and the courage to back it up, that it could be done because he had seen the very successful results in the electrical industries.

There is a great difference between the electrical and metallurgical industries, and one of the major points that I want to bring out is the fact that there is a reason why the electrical industries are today the foremost organized development companies. One of the reasons is because the history of the electrical industry's growth has been one of laboratory development preceding plant production. Mr. Craft has carefully emphasized this point.

There is another reason why there is probably more money spent today by the electrical industry on organized development than by all others combined. It is because the electrical laboratories can make, for example, a telephone; they can make a loading coil; or a vacuum tube. The same devices, the same type of men and the same machines that are used to manufacture one telephone are used to manufacture many thousands in actual production. You may reorient these machines, build them in gangs and so on to get the work through most economically, but the Research Department turns over to the Manufacturing Department a finished article, specifications for the same, and all the art required in its manufacture.

Now when you come to the chemical industry the problem differs a little. The Development Department turns over to the Operating Department a process which may have been carried on, on a semi-works scale or in some cases not beyond the laboratory scale. The Development Department can turn over a small amount of the finished goods, specifications for the same, but it cannot ordinarily turn over the final apparatus and the finished art. There is in the chemical world, however, a long history of turning laboratory and semi-commercial developments over into complete commercial production. These are well recognized steps.

In the metallurgical field the problem of going from the laboratory to commercial production is quite a different matter than in either of the former two cases, that is to say, the chemical and electrical. When I say "metallurgical" I mean primarily the production of metals from their ores. In the case of alloys the problem is very much simpler, and quite an art has been developed for bridging from the laboratory to the plant.

The technique of laboratory, semi-works scale and pilot unit study of ore reduction is still in a very undeveloped state, and the bridging of the gap to commercial practice is not attained by any well recognized path. The production of a few pounds, or say a ton, a day of metal in the laboratory or on the semi-works scale is always accompanied by extreme difficulties, because of the difficulty of reproducing a blast furnace, an open hearth or a retort furnace on so small a scale. A hundred or five hundred ton metal furnace is not just simply one hundred or one thousand reproductions of the development department's first unit. When one goes from a few hundred pounds to several hundred tons, the whole apparatus and art has to be redesigned in order to make use of the engineering materials of which such large scale furnaces can possibly be built. Frequently the entire process has to be reorganized to fit large scale apparatus.

In the past, development in ore reduction work has been almost entirely in the hands of the actual plant superintendents, and the reason is that the experimental work had to be carried out on a large unit, and nobody knew how to handle these big units better than the men who were most familiar with them,—the superintendents. On the other hand, these men became superintendents because they were primarily production men and not development men. You can see that, under these circumstances, development has not received the fullest measure of encouragement. and where there has been an operating superintendent full of zeal for development, he has been up against the necessity of experimenting and keeping his cost sheets in line at the same time. Some superintendents have been able to do this, but by far the greater majority have not, and the chances of maximum success in development by this method are low as compared with the success attainable by a separate organization trained in the science and experienced in the art of laboratory and semi-works try-out of new ideas.

Another point I wish to make, and this point was raised and well answered in one way by Mr. Craft, is how to go about building up the physical plant of a development organization. After some ten years' experience with our own organization, I do not doubt but that, had we originally set out and copied the Electrical Industry's model of a development department, namely, a distinct and separate organization, budget and buildings, we could have been further along than we are today. I am sure, however, from the past history of development in the metallurgical field that we could not have successfully convinced our management that such a method, so different from what had been done in the past, was the right one. What we did, and probably what any one else attempting to start up a development organization would do, is to make use of the buildings, equipment and certain parts of the organization and service facilities that the operating departments already had. In most cases this meant using idle buildings and second-hand equipment of all sorts. The initial cost, however, of doing your development in this way will not be nearly so great, and you will have the opportunity of establishing a department without frightening the directors too much with the initial outlay.

If the department is successful and grows, you will very shortly run against the difficulty that the regular production shopmen, construction men and engineers just naturally do not relish quick changes of plans. For example, a good operating shop likes the work it turns out to be permanent and when you send them a sketch today to build a device and then try it out for a couple of days, scrap it and start all over again, the shop is apt to think that it is a reflection on its ability. You will also find that the shops for operating purposes can run along at a certain degree of accuracy in their work, which is amply sufficient for production purposes, but, when you are building a laboratory or semi-works device in which you want to eliminate all variables except one, it is frequently necessary to design and build an apparatus that requires a high degree of accuracy. You have difficulty getting such a thing made in your own operating shops and much time is lost if you attempt to get it made outside. Frequently the fundamental idea is jumbled in transmission to others. The outcome of all this is that as a development department grows it will gradually build up its own instrument and machine shop, its own engineering department and its own service facilities. The next and final step is to have its own plant and buildings. Then the transformation has been made complete and you have gone over to the model set up by the Electrical Industry, which Mr. Craft has so clearly explained.

I would like to say at this time that there is just as much opposition today, and perhaps more, to new ideas and new developments as there ever was. The larger and the more successful an operating organization the more difficult development becomes. The only kind of operating organization that is ready for research, is the operating organization whose competitors have beaten it out with something else. Then it is ready for a change. The management should realize that good operating and good development are always in conflict. Good operating wants to produce each article exactly as it did each other one and, realizing that "art is long," they want to make these articles the same over a period of as many years as possible. The development ideal, on the other hand, is each article a little better than the last one. Good management brings good development and good operating together by having the development department make all the small steps of progress one at a time up to some definite stage of advance, operating in the meantime continuing, as in the past, practicing the old art. When development has gone a desirable number of steps ahead it can turn over to production the new art and the new product ready for standardization and duplication for another period of years.

It should be borne in mind, however, that there is no such thing as standing still. If there is one law of nature that seems to be immutable it is that the balance between construction and destruction (integration and disintegration) determines where we are. One or the other is predominating. We cannot stop development without giving deterioration the ascendent.

Another point brought out by Mr. Craft, and one that I want to emphasize in turn, is the common mistake as to the necessary human make-up of a research or development organization. If there is one mistake above another made by the average individual—I mean the average technical man, as well as the average layman—it is the belief that the research organization must consist essentially of an aggregation of "nuts."

If you will go up to the building on West Street that houses the Bell Telephone Laboratories, Inc., you will find that they run their business like any other business house, and the individuals make use of every modern device—and some that are years ahead—for speeding up the production and improving the quality of their product. (Their output is facts in the shape of reports, new devices and art, i. e., skill.) They have a full accounting department and are just as much interested in the cost of producing their output as if they were making one piece of a telephone assembly at their great production plant at Hawthorne. It is true that the percentage of serious minded individuals, and in some cases abstracted individuals, is naturally higher than would be coming out of a nearby merchandising office building. Nevertheless, there is no resemblance in that organization, nor in my own, I assure you, to the popular conception of a group of somewhat crack-brained inventors. The business is too highly organized and too interdependent, one part upon another, to operate with erratics. In fact, there is no necessity for erratics whatever.

If you are interested in organizing development in your company, if you want to go ahead with it, bear in mind that it is a business proposition that pays dividends if you put it on the same basis that you would put any other new department. Development, however, takes a little longer to get started than a new production department. It generally takes a development department a year or two to make a technical analysis of your situation, beginning with the raw materials and going down through the various processes of manufacture, through your own finished product down to the ultimate consumer. Only after a thorough analysis has been made is it possible to put the most work on the most important problem. Development will only reach its greatest fruit when as much is set aside each year for development as for depreciation, and remember it takes a while to develop experts.

There may be no recognized art whatever in your industry for bridging the great gap between good ideas and their physical embodiment on a large scale.

DR. CHARLES L. REESE, of Wilmington, Del.:

I am glad to say that I was not told I was to talk until I came up here. Consequently, I have been relieved of much worry and you will excuse me if my remarks are a little disjointed. My friend, Mr. Craft, has given us a wonderful talk and it has been extremely interesting from the mechanical, chemical and physical point of view. Mr. Breyer has covered the chemical industry, and I have little left.

There are, however, a few things I want to say and I have some suggestions to offer. I understand from Mr. Craft's talk that the object of this symposium is to bring out the importance of industrial research, and that is something on which I have been harping for a long time.

About seventeen years ago there was an organization created called the American Institute of Chemical Engineers, of which I had the honor to be one of the organizers. I think all of those men who organized the Institute of Chemical Engineers were chemists, but most of us had a great deal of technical experience and had been compelled to carry on engineering work.

I was abroad this summer (I happen to be President of the Institute at present) to hold a meeting with the Institution of Chemical Engineers in Great Britain. It was a joint meeting and one of the subjects of discussion was "Chemical Engineering Education." One of my questions, and I put it to a number of engineers on the way over on the steamer, was "What is a chemical engineer?" I am sure I do not know. From my point of view it is a chemist with engineering experience—because that is all the engineering I have. I can take an engineer and tell him what I want done and I will use an engineer, and in my chemical engineering work I have always used engineers. But I have told them what I want and how I want it built and if they have a better idea than I, I always adopt it. That is what most of the older chemical engineers in this country are doing. Although I am saying this to a group of engineers, I think I am right when I state that a chemist can become an engineer, but an engineer cannot become a chemist, unless he stops to study chemistry. A chemist can learn to be an engineer—some kind of an engineer—from experience.

I have found it very difficult to find engineers trained in research methods. The engineering laboratory as a rule falls behind the chemical laboratory for two reasons. One is that the number of problems are very great and the chemical knowledge is growing so fast that we cannot keep up with it. Of course there are just as many engineering problems but we do not see them. Why is it? It is because engineering is not a science; it is a profession which applies scientific principles. But there are lots of engineering research problems which should have men trained in research methods to solve, and the only place to train these men in research methods is in some research organization or in our universities. We need that more than anything else. We need schools of mechanical engineering research. I have never heard anybody say that.

I am a member of the National Research Council and they are trying to advance engineering research. but gentlemen there are no men in the engineering profession who are fundamentally trained in engineering research methods that I know.

I hope that everyone and all of us who are able will try to preach the importance, not necessarily of industrial research, because that is bound to follow, but of fundamental research. What I mean by fundamental research is exactly what Mr. Craft has told you —going down to the root of the thing by studying the fundamental principles involved in the problem.

We have been hearing about a machine for making phonographs. What was the trouble? New inventions were nearly putting that business on the rocks. What did they do? They went to this laboratory that has all this fundamental information on their shelves and they got "out of the woods."

I was talking to a gentleman connected with the National Carbon Company; he remarked, and you all know that this is true, that not many years ago every street corner had a carbon arc lamp on it. Today there is only one town in the country that has any carbon arc lamps. Every one of those lamps had to have a new carbon put in it every day. If it had not been for the automobile business—storage batteries and the radio,—those people would have been out of business. But other uses came along. They did not start either of them, but they have started a great big research organization, because they have seen "the handwriting on the wall."

In every organization—every manufacturing organization, and even commercial ones, you might say it will pay to have men trained in research methods—engineers and chemists. They could show their value within a very short time. If a laboratory is too great an expense then hire a chemist or Chemical Engineer at the wages of a good mechanic, it can be done; get a young man, of course—a fellow full of enthusiasm. Then turn him loose or make him follow a particular job, but give him the opportunity to come to you and say, "If you do this so and so you will save money."

DR. HAROLD PENDER, University of Pennsylvania:

Mr. Reese made the statement toward the end of his talk which I am afraid may give the wrong impression to some of the younger men here; that is, that one can hire a research man for the price of a mechanic. I do not know, however, whether you all heard what he said at the end and I want to make sure that the last part of his statement got across, namely, that if at the end of three or four years he is not receiving a much larger salary, then he is not much of a research man.

The research man is employed very frequently at a very low salary at the start, but I do not know of any other line in which a young man has a better chance of getting rapid advancement than in research, provided he is A-1. If he is not A-1, he won't get very far in any line of engineering.

In regard to the training of research engineers, Mr. Reese made another statement that the best kind of chemical engineer is a chemist with engineering experience. Similarly, in the other branches of engineering what we need is a man who is a physicist with engineering experience, and until we get more of that type we will not have research engineers. The student at the university is too eager to get the lingo of engineering, so that he may be able to talk about the various kinds of machines, and he wants to get it in a hurry and then get a money-making job. He does not want to enter into that "diligent investigation" which is contained in the definition of Research.

Municipal Financing

It is rather the exception for cities to make plans for public improvements and finances years in advance. Detroit has attempted it. Last December the Mayor of Detroit appointed two bankers and three manufacturers as a Special Committee on Finances to prepare a comprehensive financial program for the City for 10 years or more. The report has been printed in *Public Business*, the bulletin of the Detroit Bureau of Governmental Research.

Upon request, departments and commissions of the city presented estimates of the projects which they believed were necessary in the next 10 years. These totaled $780,000,000, excluding $108,000,000 for city planning projects, and $112,000,000 involved in port development and super-highway plans not considered by the Committee.

Immediately it was found necessary to postpone certain projects beyond the ten year limit and to eliminate others. The recommendations were based on a thorough study of the various plans and a classification of projects on the basis of their urgency. The total was finally reduced to $441,990,875, or forty-four and a half million dollars a year for ten years.

How the Committee arrived at this distribution, what conditions determined their decisions, the question of assessed valuations and tax rates are all interesting to the municipal government officials.

This is budgeting on a large scale—not for one year at a time but for ten years in advance. It may be profitable to watch such cities as Detroit to see how such plans may help to eliminate waste and bad management in municipal government.

Automatic Train Control*

By A. H. RUDD

Chief Signal Engineer, Pennsylvania System

PLEASE understand that I am not criticizing the Interstate Commerce Commission. The Commission is composed of 11 men. It has jurisdiction over practically every phase of railroad operation involving safety, and of railroad finance. No 11 men in the world can become experts in all these matters. They must of necessity divide the work, and also they must of necessity depend upon their experts and near experts. The salaries they are permitted to pay many of these men are not sufficient to enable them to obtain the best talent.

Most men of affairs have to face similar conditions and, if some cog slips, or some place in your organization is weak, you have to take the responsibility and the blame. The Commission is up against it. It has made a remarkably small percentage of mistakes. Among all the great problems they are called upon to settle fairly, the matter of train control is more or less of a routine matter with them, and yet, with the Signal Engineers and Motive Power men, it bulks large. It is quite possible that they exaggerate its importance. It is entirely probable that the I. C. C. as a whole does not realize it.

This paper was practically completed last Wednesday. The general situation as outlined therein is not materially changed, despite the collision near Monmouth Junction the day after.

I suggested that the subject of this should be "The Economics of Automatic Stops or Train Control." Some of the members of your "Committee on Papers" felt that this might be considered as a financial proposition and imply that the humanitarian side was overlooked, so the title was changed. Nevertheless, I propose to discuss it as an economic question.

It is a matter of common report that railroad corporations have no souls; that their managements belong to or are controlled by the predatory rich; that they oppose any safeguards which cost money unless they carry with them an adequate financial return, and, as between the sacrifice of a few lives and the sacrifice of valuable cargoes of merchandise, the merchandise has the preference, for it is a well known fact that it costs proportionately less to handle slow moving trains than high speed trains, and that on nearly all roads freight revenue is greater than passenger revenue. It would seem, therefore, that the freight traffic should be given the preference in movement and should be amply safeguarded.

"Thousands of lives and millions of dollars worth of property are yearly sacrificed because the railroads have systematically refused to spend a very small percentage of their ill-gotten gains to provide automatic stops, which will make such disasters an absolute impossibility"—for authority see the prospecti of train control company promoters.

And it is a matter of quite general knowledge that the Interstate Commerce Commission has finally ordered 49 railroads to install such devices, not on the freight lines but on main lines where passenger trains are operated.

It is, of course, true that a train standing in a terminal does no damage, and, therefore, of course, it follows that the greatest safety is obtained by stopping a train whenever there is a dangerous condition ahead, and the Interstate Commerce Commission says one of the most important functions of the automatic train stop is to "enforce obedience to the indications of fixed signals," and the Commission requires that it shall be effective "when the signal admitting the train to the block indicates Stop, and, *so far as possible,* when that signal *fails* to *indicate existing danger conditions.*"

Now let us have a few facts:

1st:—Every time an engineer opens a throttle or turns on the "juice" he does a hazardous thing. There were 6,922 persons killed in the United States in train and train service accidents in 1923, and 6,215 in 1924.

However, the function of the railroads is to operate trains, and the risk must be taken.

2nd:—After a train is started on its way and before it reaches its terminal, the safest way to operate it is to keep it moving at such speed that it will not run into another train or obstruction and will not be run into by another train; it having been found after years of experience that collisions are almost invariably caused by one train running into another.

3rd:—There *is no greater* economic waste than loss of human life. Some are of almost inestimable value; some may seem *absolutely useless* and yet even their deaths mean a loss to someone *in almost* every case; and all railroad men know this.

Therefore, in considering the economics of train control, it must be understood that its value and the place it occupies in the general economics of railroad operation are determined *absolutely and entirely* by its usefulness in eliminating or reducing fatalities and injuries of: 1st, patrons of the road; 2nd, employees, who must assume the risk incident to their employment, and which it is the duty of Management to reduce to the minimum; 3rd, non-trespassers crossing the railroads; and, 4th, trespassers.

History and statistics have value in enabling us

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*Paper read before the Engineers' Club of Philadelphia, November 17, 1925.

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to measure our progress, and profit by the mistakes of ourselves and others; also to establish the relative value of various safety devices.

Considered entirely by themselves, if the devices under discussion will save fifteen passengers a year (and they might if all the main tracks of *all* the railroads were equipped with them) and taking the *average* value of a human life at $100,000.00 (which even the most optimistic of humanitarians would admit is a liberal valuation), as evidenced by verdicts in automobile accidents, they would be worth $1,500,000 per annum to the country at large, but they cannot be so installed because *all* the capital in the world is not vested in the railroads.

It is the prime duty of the Management to handle traffic safely, efficiently and economically, and safety is the first consideration. Granting that this statement is true, and various Acts of Congress recognize and insist that it is, the *relative* and not the intrinsic value of train control must be considered, and I am here to tell you that in my opinion, as a *relative* life saver, it isn't worth the money it costs, and that the figures of the Interstate Commerce Commission prove it. What is required is a proper application of the Law of Relativity, in which I instructed you a few years ago.

Now for a few statistics. They may be dry, but they are informative. Please get the high spots. Except for freight track mileage, they are all taken from the Interstate Commerce Commission Government reports; as the latter do not give the figures of freight track mileage, these are taken from the Bureau of Railway News and Statistics.

At the end of 1924, there were in the United States, in round numbers, 250,000 miles of road, 290,000 miles of main track; and 117,000 miles of yard tracks and sidings, a total of 407,000 miles of track. The Interstate Commerce Commission reports show 197,800 miles of road and 232,000 miles of track on which passenger trains are run; this leaves 58,000 miles of main track on which freight trains are run exclusively. Of this freight train mileage, the Erie has 77 miles of track; the Reading 20; and Pennsylvania 678, and other roads about 25 miles, a total of 800 miles or less than 1.4% protected by block signals.

The same Interstate Commerce Commission reports show that, at the end of 1924, 140,000 miles out of 232,000 miles, or 60% of track where passenger trains are run were protected by block systems (not including about 150 miles on the Santa Fe at or near stations, crossings, etc., where trains are most liable to stop) and of this mileage 69,000 miles or 30% of total is equipped with automatic signals.

If prevailing opinion is correct, this shows how recreant the Management is to its trust. Tracks carrying exclusively valuable freight are only 1.4% protected, while those carrying cheap human life exclusively, or humans and freight, are 50% equipped.

Your attention is particularly called to the fact that 92,000, or 40%, of the passenger and freight mileage, and 58,200 miles, or 98.6%, of the exclusive freight mileage—all main tracks—are today without block signal protection, and that in addition there are 117,000 miles of yards and sidings, where cars may collide and injure freight and employees, which, so far, nobody has thought of block signaling to any extent and where no automatic stops have been ordered in.

Right here a little history may not be amiss and I'll try to outline briefly the "events leading up to the tragedy."

Where there is no block system in effect, trains operated entirely under train rules, orders and schedules, some of which rules are quoted below:

(Rule 71): "A train is superior to another train by right, class or direction. Right is conferred by train order; class and direction by timetable. Right is superior to class or direction. Direction is superior as between trains of the same class. Superiority by direction is limited to single track."

(Rule 72): "Trains of the first class are superior to those of the second; trains of the second class are superior to those of the third; and so on.

Trains in the direction specified by the timetable are superior to trains of the same class in the opposite direction."

(Rule 73): "Extra trains are inferior to regular trains."

(Rule 85): "When a train of one schedule is on the time of another schedule of the same class in the same direction, it will proceed on its own schedule.

"Trains of one schedule may pass trains of another schedule of the same class, and extra trains may pass and run ahead of second-class trains and extra trains."

(Rule 86): "Unless otherwise provided, an inferior train must clear the time of a superior train, in the same direction, not less than five minutes; but must be clear at the time a first-class train, in the same direction, is due to leave the next station in the rear where time is shown."

When trains are off schedule, they themselves or other trains may be, and usually are, operated by train orders which confer rights or restrict them.

The rules are the result of years of study and experience and cover about every contingency that might arise.

It was the custom on some roads to permit trains in the same direction to follow on a ten-minute interval. With a preceding train keeping ten minutes ahead, the time interval was effective, but sometimes they lost time between stations or unexpectedly stopped. Collisions frequently resulted. With trains on schedule and every man on the job everything was lovely, but, with some trains late, orders were required. Mistakes in orders, misreading or overlooking orders or rules, resulted disastrously; many accidents resulted, and, with light wooden cars equipped with oil lamps, coal or wood-burning stoves, the loss of life was appalling. Under these conditions, the idea of the automatic control of trains in danger zones had its birth.

The first automatic stop in America was patented July 13, 1880, by Messrs. Joseph Wood and Axel Vogt, of the Pennsylvania Railroad, tried out and discontinued. Inventors have been busy ever since. I suppose there are now 6,000 or 8,000 of them and most of them worse than the others.

Meanwhile, various block systems were invented and put in service, generally superimposed upon and not supplanting the train rules, that is, used as an added safeguard, although they have been so perfected that some of the requirements regarding superiority have been modified.

For years Mr. John J. Esch, then Chairman of the Committee on Interstate and Foreign Commerce of the House of Representatives, was an earnest advocate of the block system and tried to have laws passed giving the Interstate Commerce Commission authority to compel their adoption. Finally his opportunity came and, as joint author with Senator Cummins of the so-called Esch-Cummins Bill, now the Interstate Commerce Law, he included Section 26, giving this authority to the Interstate Commerce Commission, of which he is now a member.

Your attention is especially directed to four words in this Law: The Commission may order a railroad to install automatic train stop or train control devices *"or other safety devices."*

Included in the "other safety devices" are the various block systems, interlockings, etc., *which Mr. Esch wanted years ago,* but, as far as I have been informed, I do not know of a single case where a block system has been ordered in directly on a foot of territory, though thousands of miles of road have been ordered to put in automatic stops or speed control. The Commission is not a unit on this matter:

Despatch from:

"Washington, Oct. 22.—The Interstate Commerce Commission today ordered the Great Northern Railway Company to install an automatic train control device on the 106 miles of its line between Williston and Wolf Point, in Montana, in spite of a petition by the railroad asking to be relieved of the expenditure.

"Commissioners McManamy, Hall and Eastman dissented from the ruling and Commissioner McManamy held that 'a clear showing has been made that greater safety will result from an extension of automatic block signal system upon which train control can be superimposed if and when conditions warrant, than from the same amount of money spent in the installation of the more complicated and expensive train control devices required by our order.' "

The Congress in 1906 authorized the Interstate Commerce Commission to investigate train control and the use of automatic block signals. At that time, about 50,000 miles of track in the United States was block signaled, about 7,000 of this being automatic signals. As stated awhile ago, we now have 141,000 miles of track voluntarily protected by block system, increased 91,000 miles, and 69,000 miles of automatics, an increase of 62,000 miles—almost three times the mileage of block systems and ten times the mileage of automatics than in 1906. The Pennsylvania alone has an investment of approximately $27,000,000 in signals and interlockings.

It is evident that conditions have greatly changed since the promoters of automatic stops began to get in their work.

In addition to the block systems, we have better roadbed, improved brakes, steel cars, electric lighting of cars and electric headlights, more reliable signals of greater visibility day and night, and numerous other safety devices, such as approach locking and route locking at interlocking (which prevent signalmen from making mistakes) mechanical and electric checks on the block system, and, as important as any of these and perhaps more so, better discipline due to efficiency tests, better living conditions, so that men may devote their thoughts to their work and keep alert, shorter working hours, rigid physical examinations, checking of the condition of an engineman before he goes on duty, etc., etc., all of which have tended to cut down the accidents due to human inefficiency and inattention, during the past 20 years.

Accidents due to railroad operation caused an average number of deaths for the years 1919-1922 inclusive of 4,157; the average number of deaths due to *all collisions* averaged 201 per annum.

In 1923—7,385 people were killed; in 1924—6,922.

The time is too short to analyze what caused these deaths in each year. We may take 1923 and 1924 as the latest statistics available.

ACCIDENTS

I. C. C. REPORT—STEAM RAILROADS—FOR YEAR ENDING DECEMBER 31, 1924, AS COMPARED WITH 1923

(In collisions of all kinds, including those in yards and on sidings, etc., where there is no signal protection).

	1923.	1924
Number of collisions	7,115	5,166
Number of derailments	16,708	14,259
Number of locomotive accidents	1,038	802
Miscellaneous	2,636	2,141
(*) Grand Total	27,497	22,368
(*) Of this grand total, those occurring at Highway grade crossings were	66	63

KILLED: (Collisions):		
Passengers	9	11
Employes—all classes	112	85
Other non-trespassers	5	7
Trespassers	8	6
Grand Total	134	109
Average number of passengers killed per collision	1 in 790½	1 in 470
Average all classes killed per collision	1 in 53	1 in 47⅓
KILLED: In Derailments:		
Passengers	32	30
Employes—all classes	115	97
Other non-trespassers	25	23
Trespassers	43	31
Grand Total	215	181
KILLED: In *all* train accidents:		
Passengers	42	41
Employes—all classes	275	216
Other non-trespassers	43	71
Trespassers	52	39
Grand Total	412	367
KILLED: At highway grade crossings:		
Passengers	1	2
Employes—all classes	33	32
Other non-trespassers	2,101	2,008
Trespassers	133	107
Total	2,268	2,149
Not included in above, various, run over, struck and killed, not at public crossings	2,618	2,333
TOTAL KILLED:		
Getting on or off cars or locomotives	539	495
Coupling and uncoupling cars or air hose	130	93
Coming in contact with fixed structures	69	63
Miscellaneous	852	719
Total	1,590	1,370
PASSENGERS KILLED:		
In all collisions	9	11
Derailments	32	30
Miscellaneous	1	
Total—Train Accidents	42	41
PASSENGERS KILLED:		
Coming in contact with fixed structures	2	0
Getting on and off trains	41	61
Struck or run over, not at public crossings	34	25
Miscellaneous	19	22
Total	96	108

Now let us disregard for a few minutes the deaths of employes, non-trespassers and trespassers, and study the causes of the collisions where 9 passengers were killed in 1923 and 11 in 1924.

In 1923, 8 were killed in rear-end collisions due to disregard of stop signal, and 1 at a railroad crossing. All are charged to negligence of employes. Statistics do not show under what sort of operation these occurred, but they do show that not one was due to faulty equipment, and that 24 passengers were killed by trains running into washouts; one passenger, automobile struck by train. They show that in the eastern district, 3,530 people were killed; of these, 145 perished in *all* train accidents, 3,194 in train service accidents and 179 in non-train (including industrial) accidents. In 1924, 9 passengers were killed in collisions of 2 or more passenger trains and 2 in collisions of freight and passenger—total 11.

As stated, I cannot find statistics showing system of protection under which passengers were killed, but the following is illuminating: Under the train order system, of 60 collisions in 1923, due to carelessness of employes, 17 occurred in manual block (12 of which, due to overrun meeting point, *complete manual block would have probably prevented*)—(EXPLAIN WHY)—none in controlled manual block, 3 in automatic block, and 40 in no block territory; and, in 1924, of 47 such collisions, 16 in manual block (10 overrun meeting point) none in controlled manual, 2 in automatic block and 29 in no block territory.

In short, there occurred on the 30% of track equipped with manual block, 28⅓% of the collisions in 1923, and 70% of these are questionable; 34% in 1924, and 63% of these are questionable. Not a single one occurred in controlled manual block territory. On the 30% of automatic block, where the traffic is thickest, 5% of the collisions in 1923, and 4¼% in 1924, and, on the 40% non-block territory, usually the lines of least traffic, 66⅔% of the collisions in 1923, and 61.7% in 1924. This shows the value of block systems.

Train stops and train control will *not* prevent the following accidents:

Washouts,
Boulders on track,
Trees falling on track,
Obstructions on account of close clearance, such as crane fouling main track, or train on adjoining track buckling,
Slides
Broken rails, where contact is preserved,
Automobiles and trucks on crossings,
Runaway cars,
Collisions at slow speeds,
Collisions occurring where train has been stopped by train control and is proceeding.

As above stated, collisions are about the only class of accidents which may be prevented by train control, although possibly a few derailments might also be prevented, especially where speed control features are used, but on the other hand there are a large number of collisions, particularly those occurring in yards, that would not be prevented, and while each of these may be accountable for a small number of injuries or deaths, the total is an appreciable percentage of the whole number due to collisions.

I will mention a few facts, apparently not widely known, and correct a few of the misapprehensions and misunderstandings which are unfortunately widely prevalent—to tell you why we are forced to do this work and some of the conditions surrounding it and the problems involved.

Section 26, Interestate Commerce Act of 1920 provides:

"That the (Interstate Commerce) Commission may after investigation, order any carrier by railroad subject to this act, within a time specified in the order, to install automatic train stop or train control devices, *or other safety devices,* which comply with specifications and requirements prescribed by the Commission, upon the whole or any part of its railroad, such order to be issued and published at least two years before the date specified for its fulfillment."

January 10, 1922, the Commission ordered 49 railroads to install by July 1st, 1924, automatic stop or train control, but gave them until March 15, 1922, to show cause, if any, why the order should not be entered.

Extended hearings were held and on June 13, 1922, order 13413 was issued, requiring the 49 roads to install on or before the 1st day of January, 1925, "an automatic stop or train control device or devices applicable to or operated in connection with all road engines running on or over at least one full passenger locomotive division included in the part of each such company's *main line* between points hereinafter designated," and which the Commission thereinafter designated.

The Pennsylvania R. R. System was ordered to equip three divisions—one of three divisions on the Pennsylvania Railroad between Philadelphia and Pittsburgh (afterwards changed to the Line between Harrisburg and Baltimore); one of two divisions between Pittsburgh and Indianapolis on the P. C. C. and St. L.; and one on the W. J. & S. R. R. between Philadelphia and Atlantic City (afterwards changed to the steam line between Camden and Atlantic City).

All the roads were required to file plans and begin the making of progress reports monthly after January 1, 1923; six months being allowed for experimentation and decision, except that, in view of the Pennsylvania Railroad's offer to install an experimental section of 50 miles on its Lewistown Branch and Williamsport Division, 45 miles single track and 5 miles of double track, no reports were required of the three divisions mentioned or of the Norfolk & Western and Long Island Railroads until July 1, 1923, giving a year for experimentation, but *not* extending the time of final completion and provided that the Pennsylvania Railroad began to report on this installation in July, 1922—six months before the other roads had to.

This experimental device was of the continuous induction type actuated by track circuits and had never been developed outside the laboratory.

A second order issued January 14, 1924, required us to equip the other division on the P. C. C. & St. L. and one engine division of the three between Philadelphia and Pittsburgh on or before February 1, 1926.

The law provides that the penalty for refusal or neglect to comply with any order is $100.00 for each day that such refusal or neglect continues, which may be recovered in a civil action brought by the United States.

It will be noted that, contrary to the impression prevailing in many quarters and fostered by several interested parties, the law does not require the Commission to order in such devices—it says the Commission *may* do so.

The law further provides "That a carrier shall not be held to be negligent because of its failure to install such devices upon a portion of its railroad not included in the order; and any action arising because of an accident happening upon such portion of its railroad shall be determined without consideration of the use of such devices upon another portion of its railroad."

Order 13413 required the installations on portions of *main lines only.*

An examination of the reports on collisions resulting in fatalities made by the Bureau of Safety to the Interstate Commerce Commission, discloses a rather curious coincidence; almost without exception the following stereotyped sentence appears among the "Conclusions": *"Had an adequate block system been in use on this line, this accident probably would not have occurred. An adequate automatic train stop or train control device would have prevented it."* It is noticeable that practically none of these collisions have occurred within the limits prescribed by the order and yet each report reiterates the statement. Of course, where an accident occurs in block signaled territory, the first clause is omitted; also, of course, the entire sentence is omitted in cases of derailment due to broken equipment, etc. Nothing is said of other things which might have been useful.

Last Thursday at Monmouth Junction, we had one of the worst collisions in years. In 1923 we did not kill a passenger in a collision on the Pennsylvania R. R. System. In 1924 we killed one each in two collisions, neither of which would have been prevented by automatic train control and one in a derailment. In 1925, until last Thursday, we had a clean record, and then in one crash we killed 10 passengers, 1 employee and 1 Pullman porter, and injured 30 others. All our records for three years smashed in an instant. This occurred where we had automatic signals, operating properly, and not in a section which we have been ordered to equip with train control. The report of the investigators of the Interstate Commerce Commission will say: "An adequate train stop or train control device would have prevented it." Accidents of this kind have greatly influenced the Interstate Commerce Commission in its orders requiring automatic train control on certain sections of railroad.

In connection with order No. 13413, the Commission laid down 17 requirements, one of which has since been changed, and another modified by interpretation of two members of Division No. 1, which consists of three members of the Commission having these matters in charge.

In these requirements the Commission says: "*In prevailing practice the primary function of automatic stop or train control devices is to enforce obedience to the indications of fixed signals;* but the feasible operation of essentially similar devices used without wayside signals may be regarded as a possibility."

General Requirements

"1. An automatic train-stop device shall be effective when the signal admitting the train to the block indicates stop, and so far as possible when that signal fails to indicate *existing* danger conditions.

"2. An automatic train-control or speed-control device shall be effective when the train is not being properly controlled by the engineman.

"3. An automatic train-stop, train-control, or speed-control device shall be operative at braking distance from the stop-signal location if signals are not overlapped, or at the stop-signal location if an adequate overlap is provided."

NOTE:—It is presupposed that these devices operate in connection with fixed signals.

At the time of the first order, there were in actual operation on the Boston Elevated, New York Subways, P. R. T. and some other electric railroads, and, in the electrically-operated Hudson and East River Tubes of the Pennsylvania Railroad in New York, mechanical or power-operated trip stops applying the emergency brakes, and three devices of the ramp type, with contact shoes on the engines, on three steam roads, namely, the American or Hendricks on the C. & O., the Miller on the C. & E. I., and the Regan on the Rock Island, and these three latter installations were cited by the Commission as in successful operation as proof that such devices had passed the experimental stage (which the railroads denied) and as justification for the wholesale order issued.

Mr. Frank J. Sprague, an engineer of such national and international reputation that no further identification is needed in this presence, had been working for several years on an intermittent induction device, but it had not been fully developed in actual operation.

All of the devices in use at the time of the order operated in connection with *fixed signals,* and could not be used in practical operation without them.

In the light of this knowledge, let us read again the paragraph referred to—(top of page 18). The block system in itself is recognized as an efficient safeguard. The paragraph implies that either it or a train stop might be used, whereas the train stop must be super-imposed upon the block system. In short, in order that a device may enforce the signal indications, it appears necessary to provide signals that give the indications to be enforced. This appeared almost axiomatic, and, if the sentence were changed to read: "Had an adequate block system been in use this accident probably would not have occurred; an adequate automatic train stop or train control device, used in connection with this block system, would have prevented it," it would sound a little less like propaganda.

In justification of its order, the Commission cited the three steam railroad ramp installations, saying, "each of which shows a high degree of efficiency," and called attention to the number of collisions from January 1, 1906, to December 31, 1921—26,297 head-on and rear-end collisions, 4,326 killed and 60,682 injured; damage to railroad property $41,000,000, average number killed per annum 270. The Commission quoted figures to show that the Regan device, including speed control through the caution block, cost $884.00 per engine and $460.00 per ramp; the Miller stop and forestaller, C. & E. I., $500.00 per engine and $300.00 per ramp; C. & O., engine $900.00, ramp $200.00 each. *These figures did not include* the signals. The costs of induction devices were much higher.

As the ramp devices were the only ones the Commission knew anything definite about, and as the first cost figures furnished them seemed to them reasonable, they naturally favored the ramp devices as simple and inexpensive and placing a comparatively light burden on the railroads. They also appeared to favor some type of speed control.

The Miller system, one of those devices which showed "a high degree of efficiency" and the least expensive of all, consisted of a ramp which set the braking apparatus in motion whenever a train passed a caution signal unless the engineer, "being alert," operated a counteracting or annulling device as the train passed over the ramp; if he did this, he could proceed as he pleased. The requirements issued, however, under Function No. 1, provided:

1. Automatic Train Stop—*without manual control* of the engineman, requiring the train to be stopped;

after which the apparatus may be restored to normal condition manually and the train permitted to proceed.

And in the definitions:

Automatic Train Stop—The application of the brakes until the train is brought to a stop.

These provisions, of course, outlawed the Miller, and when later the C. & E. I. petitioned that their installation be accepted as filling their assignment and meeting their requirements, the Commission replied: "Petition denied."

The American on the C. & O. had originally been installed without wayside signals; it couldn't be operated, so signals were installed. If two trains were to meet, several stops, in some cases as many as seven, were required to reach the meeting point so they also installed an annulling device and, of course, that was barred out.

The Regan was installed with an overlap of 1,100 to 2,500 ft. in length. If the caution signal was displayed, brake application resulted which could be released by the engineman after speed had been reduced to about 37 miles per hour; another application was received at the stop signal if train overran it, which would stop the train in the overlap, with the proviso that the engineman might annul this stop feature if he did so as his train was passing over the ramp at the stop signal and running at a speed not exceeding 10 miles per hour.

This overlap, of course, reduced the track capacity somewhat. Under the provisions of the order, the busy railroads were *forced* to adopt some form of speed control, the Regan device being then the only number of adequate reasons; the principal of which ramp device with such control.

The roads were unanimously opposed to the use of ramps and contacting devices on the engine for a were: variation in clearance diagrams on different roads, non-interchangeability of power and the difficulties where detours were made to other roads on account of wrecks or because of joint traffic arrangements. They, therefore, began experimenting with various induction types. The Commission allowing them six months for this purpose, a very short time considering the importance of the subject.

The second order was issued against the 49 railroads and a number of others, additional hearings were held, and considerable evidence submitted as to the desirability of modifying the specifications prohibiting the use of an annulling feature on the straight stop device. Therefore, in July, 1924, the Commission relieved the railroads included in the second order, but not in the first from installing, and restored what is known as Function 1-B, which was in the original specifications of the railroad associations, namely, "Automatic Stop—B—Under control of the engineman, *who may, if alert, forestall the application* of the brakes by the automatic train-stop device, and control his train in the usual manner in accordance with hand-signal, or under limits fixed by train order or prescribed by the operating rules of the Company."

This, of course, changed the entire status and the installation on the C. & E. I. was in effect approved. The courts decided that this was a new order and, therefore, the railroads had two years from the date of it in which to install. As this decision has not been appealed, it resulted in an automatic extension of time until July, 1926, before fines would run.

A considerable number of the railroads, which had not completed the installation, decided on this method, some using the intermittent stop and forestaller; some the continuous track circuit device. All of these cost more money than the stop device on which the order was based.

The intermittent stop and forestaller will, if operative, stop a train whose engineman has missed a signal entirely, or who has misread the signal, unless he operates the forestalling device as a matter of habit. If he has so annulled, he may run at any speed he pleases until he reaches the next signal. With the continuous device, he may do the same thing, but, if conditions become less favorable ahead while he is at any point in the block, he will receive warning and, unless he again forestalls, will be stopped.

Speed control may be one speed, two speed, or three speed. One-speed requires that, if he wishes to annul the operation of the device, he must be proceeding at low speed. Two-speed may consist either of a maximum-speed governor working independently of the control and the slow speed referred to, or may require reduction of speed at the caution signal and a further reduction at the stop signal before the stop feature can be annulled. Three-speed consists of the latter device just described, with a maximum speed governor in addition. With speed control, excessive speed at various places may be guarded against. As these various features are added, the cost and complication of the apparatus increases.

There is no doubt that a stop and forestaller properly installed and maintained will prevent a small number of wrecks or at least minimize their disastrous effects, and that speed control will perhaps eliminate some others.

Considered entirely by itself, its use would be justified on parts of many railroads, but it should not be so considered.

The Interstate Commerce Commission has authority to order in other safety devices. We have shown the advantages of the block system, especially the automatic. We must admit that under this we have some accidents and an occasional loss of life, which the devices advocated would prevent. We must recognize that the extension of the block system would prevent more accidents, and that the one item resulting in the greatest loss of life in railroad operation today is the highway grade crossing; that the extension of the block system—and using the words of the Interstate Commerce Commission reports, "an *adequate* block system"—would result in greater safety to a greater number than similar amounts spent for train stop or train control; that similar amounts spent for the protection of highway crossings would, except in the case of the unfit driver, save even more lives.

The report of the First National Conference on Street and Highway Safety, called by the Hon. Herbert Hoover, Secretary of Commerce, and held in Washington, D. C., December 15 and 16, 1924, states:

"The elimination and protection of grade crossings are of such importance and involve to such an extent the public safety as to require that propriety be given to them in the allocation of capital funds by the railroads and of public moneys for highway building, over expenditures for other safety measures designed to protect the public."

Steel cars, electrically lighted, are far safer than wooden ones. There are many other things in other Departments which require large sums of money, but, taking my own Department alone, if our people were in a position to give me all the money I could spend, I would first install automatic block signals, with A.C. track circuits and light signals without moving parts on our double and more track lines; controlled manual block on important single track lines, later putting in automatic signals for following movements; adequate warning to the public using the highways of approach to a railroad crossing, and at many places automatic signals indicating the approach of a train; extension of manual block to lines where it is not now in use, which, in our case, are those used exclusively for freight service, unless, as a matter of economy, it were better to install automatic signals. On the completion of this work and as a final precaution, I would install continuously controlled two-speed cab signals on the lighter lines and three-speed on the heavy traffic lines superinstalled on the signal system, one for the engineman and one for the fireman, which would do all the complicated automatic train control does unless the engineman and fireman were both incapacitated at the same time. Meanwhile, I would develop on a trial section the actual train control apparatus, so that, if it were conclusively shown that further safeguards were needed, a simple device could be superimposed as a final precaution.

The foregoing, in view of the collisions we had last week at Monmouth Junction, may seem heartless and unwarranted, but, taking our accident records at grade crossings, since January 1, 1925:

1925 Automobile Accidents, P. R. R. System

Automobiles Struck by Train

	Accidents	Killed	Injured
January-March	198	58	287
April-June	162	52	239
July-September	184	81	234
Totals for 9 Months, 1925	544	191	760

Nine months—273 days, 544 accidents. Average, 2 per day.

Every 10 days, 7 persons killed in automobile grade crossing accidents on the Pennsylvania R. R. System.

A characteristic story is told of President Coolidge, when he was State Senator of Massachusetts: After an oration of several hours by the advocate of a bill, who iterated and reiterated at the beginning of each subhead: "It is a fact that, it is a fact that"; Senator Coolidge arose and replied: "Mr. President, it isn't." Paraphrasing him: The great thought underlying the use of train control is that it eliminates the human equation. It doesn't. It may guard against a mistake of the engineman, whatever its cause, but it will not afford this protection if the man who installs it or maintains it makes a mistake, and these mistakes have been made and are made by the best men in every walk of life, and the railroad man is no exception. If such mistakes are made, if the signals indicate Proceed when they should indicate Stop, if the automatic stop device fails to operate at the critical time, when perhaps the engineman is depending more or less upon it, the situation is, under such conditions, worse than if such device did not exist.

If the installation of these devices is forced to such an extent that they become general, the results as between a man who runs the engine and the man who maintains the apparatus may be such as to require a reranking of various classes of railroad labor.

It is claimed, and apparently properly so, that, in view of the varying weights, speed, and makeup of trains, varying efficiency of the air brakes, varying atmospheric conditions, etc., no two trains are braked alike—those who ride our trains realize this and the important part the human equation plays. With the apparatus always applying the brakes in one particular way on all these various classes of trains, will the results be better or worse than at present?

These are points well worth considering.

AS TO COSTS

Lewistown Branch

3-Speed Continuous Control—Experimental Installation

First cost of installation to July 11, 1923, when apparatus was placed in service	$285,000.00
Expended since July 11, 1923, to date (10-31-25) for development work	45,000.00
Total Installation and Development	$330,000.00
Expended on maintenance since July 11, 1923, to October 31, 1925 (approximate)	$ 89,000.00
Total	$419,000.00

Maintenance Chargeable To:

		Average Per Mo.
Roadside Apparatus	$ 43,500.00	$1,582.00
Locomotives	38,000.00	1,382.00
Electric Current	7,500.00	272.00
Totals	$ 89,000.00	$3,236.00

Average cost of maintenance per mile, per month	$ 37.00
Average cost of maintenance per engine, per month	110.00

(Based on 50 miles of road—12½ engines).

Stop and forestaller, with signals, Baltimore to Harrisburg, appropriation:

Interlocking at York	$ 78,000	
Automatic Signals	883,641	
		$ 961,641
Train Stop—Wayside	$135,042	
187 Engines at $2,600.	486,200	
		$ 621,242
Total		$1,582,883

Miles of road	83.24
Miles of track	166.29

Average cost per mile of double track—Signals	$11,553
Stop—wayside—per mile double track	1,622
Engine equipment per engine	2,600

We have no detailed estimates for the other divisions, but applying these to:

Camden and Atlantic City:

58.4 miles of double track.

59 assigned engines, and equipping 158 at $2,600—$410,800. Roadside, $94,725, where we have signals, but where they would have to be changed at about ⅔ cost of entirely new—$449,797 .... $ 955,322

Panhandle:

Approx. 340 miles double track, Signals	$3,928,020	
340 train stops	551,480	
471 engines at $2,600	1,224,600	
		$5,704,100

Middle Division:

Where we have signals, 130.4 miles of road and 422.8 miles of track at $1,000 per mile of track	$ 422,800	
231 engines	600,600	
		$1,023,400
Grand total—Rough Estimate		$7,682,822

Control only $3,926,247.

If speed control is provided, the cost will be approximately $1,150,000 more, based on the cost of speed control as installed on our Lewistown Branch. We believe, however, that the new and simplified development can be provided for at least 40% less, or at an additional cost of $700,000.

Cost of grade crossing elimination varies from $40,000 or $50,000 in outlying districts in hilly country to double or more in towns—perhaps a fair average cost per grade is $75,000. Authorities differ. A highway crossing can be protected with flashing lights on single or double track for from $1,800 to $2,500, on four-track up to $10,000 to $15,000.

A steel coach costs from $25,000 to $27,000.

A steel Pullman costs about $50,000.

Do your own figuring.

Lastly, there is one other economic question, in connection with train control, and that is the amounts of money which the public has invested in the stocks and perhaps in some cases the bonds of the promoters of train control manufacturing companies, and from which in a large number of cases they will receive no returns.

I've presented the case as I see it.

Judge Prouty, head of the Interstate Commerce Commission, once said at an A. R. E. A. dinner in Chicago, shortly before he died: I am a lawyer, but I have learned after years of experience that a lawyer is prone to have his viewpoint colored by his client's case, but an engineer analyzes; he thinks straight; he works straight, and he plays straight.

DISCUSSION

A. H. YOCUM, Signal Engineer of The Reading Company: I have been requested to say a few words on the subject of Automatic Train Control. Mr. Rudd has just shown very clearly that the introduction of Automatic Train Control can take care of only a small percentage of the accidents that are liable to occur in the operation of trains. He has also shown you how the enormous expenditure that has been forced on the Railroads by the I. C. C.'s order could probably have been spent to much better advantage on such other safety devices as extension of automatic signalling, interlocking hand thrown switches, improved track, and provision for protective devices at, or elimination of, highway crossings.

It is axiomatic that any increase in the cost of a staple commodity must be borne ultimately by the consumer; railroads produce and sell transportation.

We, all of us, are either directly or indirectly purchasers and consumers of this transportation and are, therefore, vitally interested in its cost. It is only when a train loaded with passengers or merchandise is actually moving along the road that a railroad is producing the only commodity it has to sell. The efficient operation of a railroad, therefore, demands that freight and passengers shall be moved from place to place cheaply with speed and safety. Any lowering of efficiency is reflected ultimately in additional cost to the public.

The factors of speed and safety are both demanded by the public. Speed is something tangible, it shows on the schedules, you can feel it, see it and measure it. Safety is elusive, we think we have it and find we have lost it in absolutely unforeseen ways. We employ our factor of safety and yet can only obtain a degree of safety. There is no absolute measure by which we can know the degree attained and our only guide is obtained by noting the number of failures or accidents compared with the number of movements. Speed and safety are equally demanded by the public who must be served, they know when they have the one, they *think* they know when they have the other.

The record of automobile accidents shows how worthless popular judgment is regarding safety.

The installation of Automatic Train Control on the Atlantic City Railroad, with a distance of 55.5 miles of road, has cost the Reading Company over half a million dollars.

I will not take up your time with a technical account explaining why the system which we have installed should cost so much, but I must state that very careful consideration was given by the Train Control Committee of the Reading Company to determine which system would best suit our purpose and the system installed was adopted as being, in our estimation, most likely to meet with the I. C. C.'s requirements, least likely to unduly interfere with traffic and probably most free from the new sources of danger which are liable to be introduced when new apparatus is added to roadway or locomotives.

Briefly, the I. C. C.'s order covers control of two descriptions, either that a train approaching a "stop" signal shall be brought to a stop before entering the danger zone, or that certain speed limits shall be fixed as being appropriate for certain track conditions and that the brakes shall be applied automatically, should the train exceed the limit set for the condition or the indication under which it is running.

In July, 1924, when our installation was half completed, the I. C. C. made a modification to the first-class of control so that if alert the engineman could forestall the brake application and proceed without the necessity of stopping.

It will be seen then that at present the minimum I. C. C. requirement is that when approaching a "stop" signal an engineman shall show that he is alert and aware of a dangerous roadway condition and the alternative requirement is that the engineman in addition to being alert shall control his train in a predetermined manner as he approaches the dangerous roadway condition.

When the first passenger train ran one hundred years ago it was preceded by a man with a flag on horseback. This horseman served two purposes—he warned people that the train was coming, and he made sure that there were no obstructions on the track. Incidentally he considerably restricted the speed of the train. This sounds like 100% safety. I suppose now-a-days that would be called Continuous Control, although no provision was made for ensuring that the engineman was alert and would not over-run his flagman, should the latter indicate stop.

The one who devised that method of protection doubtlessly thought it ideal. Today we see how utterly ridiculous it really was. Stephenson realized how impossible it was directly his train started. After going a few miles he called to the flagman to get out of the way. Right there the problem of Railroad Engineers became apparent—how to move trains quickly and safely. The fundamental idea of Railroad Engineers was the same then as it is today—to make Railroading practical and yet safe. We are still looking for that ideal system that will fully protect the train, protect those who lawfully cross the railroad and still enable trains to be moved with such speed as will adequately serve the public.

The money available for this purpose is limited. The Railroad's income from the sale of transportation has many calls upon it. A portion of this income is divided among the various departments, each one of which strives to render its charge safer and more efficient than before.

The question, therefore, becomes whether the cheaper forms of Train Control will not make operating conditions intolerable, or whether by installing such system of Train Control as will still permit efficient operation there may not be a boomerang effect in that the great expenditure in this way will divert money which otherwise might have been devoted to developing and installing other safety devices which would have resulted in a greater saving of life.

FRED W. BENDER, Signal Engineer, Central Railroad of New Jersey: I am not going to discuss the considerations that led to the adoption of the Commission's order No. 13413, requiring each of forty-nine railroads in this country to install train control on one engine division. These matters have been discussed by Mr. Rudd and I feel that no amplification from me is necessary. Suffice it to say that the order was issued by the Commission and after a hearing, the Railroads were compelled to proceed with the installation of the Train Control devices at the expenditure of vast sums of money.

The original order provided that the Railroads could only install devices which had no permissive feature and a large percentage of the contracts let for train control were for systems which could be operated without the permissive device in heavy traffic territories.

The automatic stop was thus practically barred by the non-use of the permissive feature, unless a new operating practice, such as stopping trains at distant signals were adopted. In effect the permissive feature is an acknowledgment of a change in the signal indication which forstalls any application of the brakes resulting from such a change of indication. In other words if a train reached a stop signal and the Engineer operated a lever on his engine, he could proceed by the stop signal at any speed. When the Commission decreed that the permissive feature would be permitted Railroads which had not let contracts for Train Control arranged to install automatic stops with this permissive device.

The Commission ordered the installation of a second lot of train control and those who had installed the apparatus under the first order, are now in a quandry as to whether the Commission will again reverse itself and eliminate the permissive feature on train control which would mean a scrapping of many of the devices now installed, or if it will retain this feature and require the Railroads to install only the simple automatic stop with permissive features.

On the Central Railroad of New Jersey, under the first order of the Commission, we had no alternative, but to use speed control if we were to continue to keep our traffic moving and we, therefore, went to the three-speed continuous train control in the territory assigned us from Red Bank to Winslow Junction, 65.6 miles. The expenditure involved in the installation of train control with necessary new signals and siding changes, was almost a million of dollars.

The system is made operative on the engine as follows: In the rails we carry an AC, 60 cycle current moving down one rail and up the other. This current operates our track relays for the control of our automatic block signals. This current is inductively picked up by receiving coils on the front end of the engine and after passing through amplifying tubes, the current picked up is sufficiently strong to energize one phase of an AC two-element relay.

In these same rails we send a second current in the same direction in both rails which is inductively picked up by another set of coils in the rear of the tender of the engine. This is amplified by two amplifying tubes and energizes the loop or local element of or relay. The two currents being out of phase by about 90° produce sufficient torque to operate the relay contacts.

This relay in turn controls the cab indication telling the Engineer when he is in a caution block; when he is within braking distance of the stop signals and when he is in a clear block. This relay also controls Electro Pneumatic valves which will bring a train from 70 miles per hour to 40 miles per hour when passing a caution signal and from 40 to 15 miles per hour when within braking distance of a stop signal. When a change in the cab indication is not acknowledged the train is brought to a stop. The speed control is made effective by a speed governor or centrifuge on the pony wheels of the engine and this also controls the brakes in case the maximum speed is exceeded.

The action of the device is weird and is something that was not dreamed of some twenty years ago. The possibilities in the way of a cab signal which may some day eliminate the wayside signal are inherent in this system. The operation of the device has been reasonably successful. However, on a small stretch of another road, I understand that it is costing about $50,000 per annum for additional motive power department expenses in maintaining the additional equipment on the engine.

We are having numerous failures which are being rectified and some day the device will reach a higher stage of perfection. It is something that will need the closest of watching and require treatment as an experimental device for a number of years, for we do not yet know that at all times it will accomplish the results for which it is supposed to be installed.

My position in this matter is not to complain about the original train control order, which, of course, I personally feel was many times in excess of a reasonable requirement in the way of installation of train control for experimental purposes, but now that we have the device installed, I feel that we are justified in asking the Commission to hold off on further installations, until what we have in, can be perfected and to ask you, as public spirited citizens, to use your influence to see that the railroads of the country are not forced to make vast expenditures of money for further experiments until the railroads have had time, by a number of years of experimenting with the device now in, to determine whether what is installed will give the results which the Commission is asking for and determine whether it will be an asset or a liability in the way of protecting life and limb.

Mr. Warren Stone, who was head of the Brotherhood of Locomotive Engineers, said before the Commission, that as a result of the use of train control devices the worst accidents in the country are still to come. His thought was that by the failure of some of these devices some frieght trains by a sudden application of the brakes, will throw out one of their cars onto an opposing track thus wrecking a passenger train on an adjacent track, which, by no signal indication, train control, or otherwise, could be prevented from hitting the derailed cars of the freight train. As to how often this is liable to occur we do not know. We have thus far, had no failure of this kind, but as a practical railroad man, Mr. Stone's warnings are worthy of consideration.

A study of the accidents we have had on our road for a number of years would justify the conclusion that train control devices which may be installed under the order of the Commission might not have prevented any of them.

What may result in the way of accidents by reason of engineers transferring their responsibility for train operation from themselves to an automatic device which may fail to function when most needed may be imagined.

We are not trying to put a Lion in the path of progress, but we do feel that insistance on repeated expenditures for train control is putting a lion in the way of sane and needed expenditures for improvements such as block signals, that will increase safety on our railroads.

You have heard Mr. Rudd state that during 1924, there were eleven passengers killed on all the lines of the country, whereas, the automobile accidents at grade crossing resulted in the killing of several thousand people. If we are to spend money for protection of life and limb, why ought not the railroads be given an opportunity to take the money which they may find at their disposal for the protection of the grade crossings, new signals, AC track circuit, better ballast conditions; better equipment; heavier rails, etc., where results will count, rather than for the wholesale expenditures of money for a device that may, or may not, give increased protection, or as Mr. Stone says, may be inviting serious danger to the traveling public.

In any event, I feel that the present installations are sufficient to permit the railroads of the country to make a thorough and detailed study of what train control will accomplish and after the roads have experimented with them for a number of years they will be in a position to tell whether their experience justifies its continuance or extension, or whether train control should be abandoned as worthless or a menace to safe railroad traffic. We do not at the present time know and no one else in the country knows, what will be the outcome. In the meantime if we are permitted to follow this procedure the railroads will have an opportunity to spend any available money where it will serve the public safety best.

JOSEPH BEAUMONT, of New York City: I have been intensely interested in the address of Mr. Rudd as to the economies of Automatic Train Control and now desire to offer the following comments:

The subject of automatic train control has not been given the light of publicity that it properly deserves. I venture to say that no important subject requires the searchlight of truth and publicity to such an extent as does Automatic Train Control. Not necessarily publicity in the press, but rather such an understanding as will bring to the minds of operating officials and engineers the great outstanding advantages which will follow its adoption.

Automatic train control is not alone a safety proposition. It is also a vital matter affecting the earning power and the capacity of the railroads. It is important that my comments be accepted as statements of fact based upon experience and observation with an automatic train control system in actual operation on a comparatively heavy traffic division.

At the A. R. A. Signal Section Meeting at Swampscott, Mass., in September, 1924, I presented a paper showing the economical advantages of automatic train control as compared with operation with a plain automatic stop or without automatic train control. I stated at that time that one of the greatest obstacles to the economical operation of railroads is the unnecessary stopping of trains and particularly of heavy tonnage freight and passenger trains, which could be safely eliminated by the use of Automatic Train Control.

Now, before we proceed further, let me say right here that there is a vast difference between an automatic stop and automatic train control as to results. An automatic stop, such as described by Mr. Rudd and such as is being installed on many railroads, may be entirely nullified by the engineman at braking distance from the stop signal, or at the stop signal by the act of forestalling, so that the train may proceed at full speed in the face of danger. With this system there is no assurance that the train will be under control; so that operating rules necessarily require that the train shall stop at the stop-and-proceed signal, before it can proceed in accordance with such rules. There is therefore a lack of adequate protection and no economical advantages in such an installation for the reason that safety will still require that trains stop at stop-and-proceed signals to insure that they are properly under control.

Certainly, to stop such trains at automatic block signals for the purpose of instructing them to proceed under such restrictions as are provided by rule alone, is costly. Such stops represent in the aggregate a tremendous economic loss which, in the light of modern practice and experience, is entirely unnecessary.

By means of automatic train control the train ahead controls the approaching train; automatic train control to insure that degree of safety and flexibility which is so vitally necessary to satisfactory operation, must enforce low speed when danger impends, entirely regardless of the human hand at the throttle or the temporary abnormality of the mind or sight of the locomotive engineer. Under no circumstances should an automatic stop, which may be nullified by the locomotive engineer at will be installed without speed control. Automatic speed control should enforce safe speed beyond the power of the engineman to set aside, whenever there exists a dangerous condition necessitating restricted speed.

To secure that degree of protection necessary in case the locomotive engineer is not alert, the automatic train control system should stop the train at the first restrictive signal. In case the engineman is alert he should be permitted to operate a permissive release to introduce speed control in order that he may proceed at a safe speed. So much for the safety features of train control.

Now as to the business end of the problem: It may be accepted as a fact that automatic train control—including speed control—will pay handsome returns per dollar invested—probably a greater return per dollar invested than can be earned in any other way. Let us look into this.

Having installed speed control to insure safe speed when passing a stop-and-proceed signal and insuring that the engineman is alert, there is assuredly no need to stop at such signals, to insure that the train is under control, so that evidently the train may proceed past such signals without stopping. Such has been the practice on the Illinois Division of the Chicago, Rock Island & Pacific Railway for the past two years. This division, which covers 165 miles of double track and 102 locomotives, is equipped with an Automatic Train Control System, operating strictly in line with the above principles.

As to the savings due to the elimination of train stops, a systematic analysis was made during September, 1925, to determine the exact number of stops eliminated by operation under this automatic train control system. In June, 1924, based upon the reports of enginemen, properly supervised, it was found that 6,078 freight train and 485 passenger train stops were eliminated due to the substitution of low speed control—equivalent to 72,936 freight train and 5,820 passenger train stops per annum. A careful check covering 61 tests has shown that trains having an average tonnage of 2,341 tons on practically level grade will consume an average of 11 minutes 26 seconds in stopping from speeds ranging from 15 to 30 miles per hour and after stopping, to accelerate to the speed from which they were stopped. It has been very conservatively estimated that 75 per cent of this time, or 8 minutes 46 seconds, is expended in stopping from a speed of 15 miles per hour and after stopping to accelerate to the same speed. This time cannot be saved without enforced speed control and the principle of spacing trains by restricting their speed rather than by stopping them. Many times the inquiry has confronted us, why stop a train to instruct it to proceed, when means are available to operate more safely and efficiently by enforcing low speed without stopping?

Seventy-two thousand nine hundred and thirty-six unnecessary freight train stops per annum at 8 minutes, 46 seconds per stop, is equivalent to 10,379 freight train hours per annum. In this analysis we have not taken credit for the savings due to the elimination of 5,820 passenger train stops, which also amounts to a substantial figure.

In September, 1925, an additional check was made by the Rock Island to determine the results *now* being accomplished by automatic train control and again locomotive engineers were instructed to report at the end of each trip, how many stops were saved, due to operation under automatic train control. In this latter check enginemen were specificially instructed that when a train was compelled to stop (due to a train in the block) even after passing a signal under enforced low speed without stopping, that this should not be counted as a stop eliminated by automatic train control. The results of this check showed that an average of 132.1 freight train stops and 12.8 passenger train stops were eliminated per day; an average of 48,216 freight, and 4,672 passenger train stops eliminated per annum—equivalent to 6,820 freight train hours per annum, and a substantial figure for passenger trains, which has not been computed. This latter analysis was made over a 30-day period—September 15, 1925, to October 14, 1925, inclusive.

The cost per freight train hour varies with the different railroads. It is not our intention to show the savings in dollars and cents as such figures may be readily applied by any railroad to ascertain the savings on that particular line, based upon the freight train hour delay and the cost per freight train hour. It would be well to state that as a result of more smooth and efficient operation with this Automatic Train Control System the Rock Island has been able to space its trains far more efficiently under the principle of spacing trains by enforcing restricted speed at automatic block signals showing a restrictive indication and compelling the alertness of the locomotive engineer—rather than by stopping the train and then permitting it to proceed in accordance with rule alone as was the practice before automatic train control was installed.

The great problem before the railroads today is how best to increase safety and operating efficiency, and the greatest duty, how best to serve the American public. It is our desire to cooperate with the railroads in every way possible to that end. If we have contributed anything in our work to date, including the thoughts expressed and the facts presented in this discussion we are content.

MR. S. T. WAGNER: Chief Engineer of the Reading Company: I unfortunately have not had the preparation that I believe the three foregoing speakers have, but I cannot help saying a few words on one or two things in the admirable talks given us this evening. The first one I have foremost in my mind is that of the interference of the automobile with the railroad. There are two cases that I want to mention showing what an automobile will do. Between here and Reading where the lines of our Railroad run parallel with the Pennsylvania Railroad, a grade crossing was eliminated some years ago, the highway part being moved to the south of its former location, and a passageway for pedestrians placed under our railroad over an inclined approach and also underneath the Pennsylvania Railroad. After passing underneath our Road there was a step or two in the passageway going up under the Pennsylvania Railroad. Shortly after it was finished a man came along the highway, in an automobile, missed the prolongation of the driveway, turned his automobile around, drove down the foot walk and was met by these steps; he turned his machine around and went back to our station and entered complaint on account of having steps "on a highway of that kind."

Another case: I was in Chicago some years ago, staying at the home of an operating official of the Illinois Central Railroad. He had a nephew staying with him at that time, who had lived in Mississippi. The Illinois Central at that locality in Mississippi is a single-track railroad, and at the particular place in question crossed a ravine by a trestle about 30 or 40 feet high and probably 600 feet long. This man said, "Uncle, you have the d............st railroad down in Mississippi I ever saw." He replied, "What's the matter?" "Why," he said, "the ties on that bridge are so far apart that when I went across it the other night in my automobile I jumped all the way over." He had actually left the highway and had driven his automobile over that trestle to the other side of the ravine. It is hard to say where automobiles won't go.

There were one or two other points that came up tonight that interested me. In the first place Mr. Rudd spoke very fully and clearly and laid the whole matter before us as to the order of the Commission and its results. When that order reached our Company a Committee was appointed to make report to the Management as to what we should do. That Committee consisted of Mr. Yocum, our Assistant General Superintendent, the Superintendent of the Division (the automatic train control was to be placed on the Atlantic City Railroad), our electrical engineer, our mechanical engineer, and the speaker. The problem, when we first met, was confusing—probably not so much to Mr. Yocum, who knew a little more about it than the rest of us, but it was to me. We had some 8,000 different devices to choose from and we had nothing to look at except Mr. Rudd's Lewistown and Sunbury installation, and it looked almost hopeless. Here were ramps; here induction control; here all kinds of things. There was the Miller system that Mr. Rudd referred to, and the Regan system in the West. We had a multitude of others where the inventors had models, more or less perfected. There were others who had blueprints and plans; and another class had ideas, that was all. We eliminated the idea people immediately. We said, "We don't want to see you" and we soon found that we had to eliminate also the fellows who had only blueprints and nothing else to show, because we had to make the installation on a very busy road, and we did not dare take any chances. So we gradually eliminated the devices where there was nothing to go on, until we got to a half dozen, and we did practically as Mr. Rudd did in the Pennsylvania Railroad on the Lewistown Division, we installed the continuous control system with the three indications that has been described here tonight. I think we did right. I am entirely satisfied in the light of what we had at that time that hardly anything else could have been done. It was expensive, it is true. We got under the wire on the 1st of January this year and the installation has been working since. It has not, however, yet been inspected by the Interstate Commerce Commission, and nobody can tell what the result of that inspection will be.

One thing more Mr. Rudd said to which I should like to refer and then I am through. He touched on a point which I am specially interested in—the cost of eliminating grade crossings. I agree with him most heartily on what he said. For a number of years part of my job has been the elimination of grade crossings.

I was at a safety meeting at Chicago two years ago, called by the Association of Public Utility Commissioners—a most interesting meeting. During one of the sessions a gentleman from Wisconsin got up and criticised the railroads for not going along with grade crossing elimination. He said, "It is a shame. We can eliminate a grade crossing for $15,000." That made my hair—what there is of it—stand straight up. When I had a chance I referred to the statement that Mr. Rudd's Company put out several years ago when the grade crossing question was being agitated, that the cost of eliminating a crossing would be about $50,000—a most interesting statement, showing what the total cost of eliminating grade crossings on the Pennsylvania system would be. For a long time that $50,000 was all right. At the present time I believe that $75,000, (taking an average of all conditions), is a much fairer statement, and I would venture to say that with the more important of them $100,000 would be nearer the right figure. Of course, that is an average figure. It is a broad, general statement. When I made that statement, a New York Central man got up and said I was entirely too low, and then the Chairman of the Pennsylvania Public Service Commission referred to a condition at Bethlehem, Pennsylvania, where the total cost of eliminating three or four grade crossings amounted to about three and one-half millions dollars.

I could have told him of another case, where we had made studies for the elimination of three grade crossings and an alley, at a cost of four and one-half million dollars.

So you can see there is a vast difference; nobody can agree. I am sure that many of the grade crossings which the Railroads would like to eliminate would be eliminated by them by using part of the money which they are now having to use for the automatic train control.

B. R. PADMORE, Electrical Signal Inspector, Reading Company: This subject has been pretty well thrashed out by the former speakers, but there is one other point about it that may appeal to engineers, and that is we should look at it from the point of view of the right perspective. In the list of accidents and fatalities I think Mr. Rudd said that in two years, 1923-1924, there were about twenty people killed in collisions, and there were all together 13,137 people killed in connection with train operation. Those 20 people killed in collisions received far more publicity than all the rest of the 13,000 and the lay mind probably considers that the causes of those 20 deaths were the predominating causes of accidents on the railroads, and therefore the same lay mind would be concentrated upon eliminating those particular causes.

Mr. Rudd went through the statistics and showed just what percentage of all the accidents those causes covered. The railroads in the last few years have been criticised for not being progressive enough in adopting safety devices. To get a real idea of what the railroads have been doing, one should look at the I. C. C. reports of accidents. They publish a rather interesting curve which shows the rate at which deaths and injuries, due to train service accidents, have varied during the last few years.

This curve is made up to show injuries and deaths per million locomotive miles, an examination will show a downward trend to this curve and that, at the present time, injuries and deaths per million locomotive miles are little more than half what they were twelve years ago. This refers not only to passengers killed in collisions but also to all persons killed or injured in all classes of train and train service accidents.

It can be seen, then, that independently of train control there has been very considerable improvement in the elimination of accidents of all descriptions.

It would be a good thing if more people would examine this I. C. C. Report of Accidents so that they might get a fairer idea of just what the railroads have been doing to protect not only passengers but also employees. When this has been fully understood it will be realized that Train Control will actually have very little effect on the general trend of that curve.

FUEL SAVING DEVICE FOR LOCOMOTIVES

Locomotive feed water heaters, invented by Thomas C. McBride, a member of the Engineers Club of Philadelphia, are now used on railroads in 27 foreign countries. The Paris-Mediterranean line in France has purchased 39 and almost one hundred are in use on the railroads of Spain.

The locomotive feed water heater uses the latent head in exhaust steam to heat the feed water, instead of using live steam for this purpose.

The invention of this locomotive feed-water heater won a special medal from the Franklin Institute. Mr. McBride stated the other day that this heater will save anywhere from 12 to 18 per cent of the fuel consumed while the locomotive is running. The special feature invented by Mr. McBride is the use of the open type heater in compact form. A 3,000 horsepower heater is placed in a width of eight inches. A heater of this power in a stationary plant would be about eight or nine feet square and ten feet high. Such a size would, of course, make it impracticable on locomotives. In the heater developed by Mr. McBride, a very thin film of cold water from the tender of the locomotive is sprayed into the exhaust steam.

The total recovery of water from the exhaust steam is 15 to 18 per cent, of which 13 to 16 per cent comes from the locomotive exhaust and 2 per cent from the pump exhaust. This conserves the water required by the locomotive.

The best designed locomotives in 1905 developed an overall efficiency of 2.4 to 5.1, while the newest designs of today develop from 4.3 to 7.3. The fuel saving campaign of the railroads has gone ahead steadily with the mutual co-operation of railroad executives and heads of firms engaged in building and equipping locomotives. This movement is also proceeding in foreign countries. The McBride locomotive feed water heaters are now used on railways in Argentina, Belgium, Bolivia, Brazil, Canada, France, India, Italy, Japan, Korea, Philippine Islands, Mesopotamia, Mexico, Portugal, Russia, Scotland, South Africa, Spain, Sweden, and the United States.

ENGINEERS & ENGINEERING

FEBRUARY, 1926

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Engineers[*]

By HON. HERBERT HOOVER

Secretary of Commerce, Washington, D. C.

THE engineer's profession was originally recruited from the superior mechanics, and it has taken a long time for the public to grasp the fact that the engineer is no longer an artisan. I recollect not so many years ago, coming across the Atlantic with the usual smooth voyage during which I sat at the same table with an English lady of a great deal of cultivation. During the course of the voyage we had a lot of roaming conversation in regard to things all about the world. As we came up New York harbor at breakfast she turned to me and said, "Would you think me impudent if I asked you a personal question?" and I said, "No—not knowing what it is," and she said, "Well, I would like to know what is your profession, what is your business," to which I stated that "I am an engineer." "Why," she said, "I thought you were a gentleman."

That indeed is somewhat the attitude, or has been somewhat the attitude, of the world, while it grew slowly in knowledge as to what the engineer's purpose in life really was.

It has grown into the most difficult of professions in the world, a profession that requires most exhaustive training, that eliminates more men in the course of its training and in the course of practical application probably than any other profession. I don't know whether you and I could get through college now or not. There was a time when the law was looked upon as the greatest profession and the one great avenue to public life and public service. I think that was rightly the case, because there was a period in the world's history when the development of law was fundamentally the development of liberty. But with the completion of the safeguards of liberty and the turn in the development of the world towards problems of comfort, engineering has become, or should have become, the dominant profession. The engineer is indeed the most critical member of our national brain today. He should give that same devotion to public service that the legal profession has given to our country these many years. It was just on that text that I wished to dwell for a moment.

The engineers comprise a body of men who, through training and elimination, by necessity are selected on ability at precision of thought, men who are anchored to facts, whose whole background, mentally and morally, is a fidelity to the determination of the fact and dealing with the fact and truth.

Furthermore, to be successful as engineers, men must have the ability to weigh the facts and to place them in their proper perspective. In other words, here is the case of quantitative thought as against qualitative thought. There is nothing so much needed in our nation and our civilization today as a replacement of qualitative thought with quantitative thought.

We are, in our development, much dominated by the economists. As Mr. Wesley Mitchell has said, some of the economists are badly in need of a little engineering training. Theirs is indeed today very largely a qualitative science. I often think that some economists weigh the importance of economic argument by the area of paper that respective arguments pro and con require, when as a matter of fact the economic forces can to some degree, in their results at least, be measured quantitatively, and it is often the case that one adverse argument quantitatively will outweigh forty favorable arguments qualitatively.

So that we need a cross-breed here between the engineer's thought and the economist's thought, because between the two of them they are dominating modern civilization. I see no way that the engineer's approach to problems, the engineer's views and vision, can be applied to public questions unless the engineer himself will come out from his office and offer himself up for sacrifice along the front with the economists.

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[*] Address before a Regional Meeting of the American Institute of Electrical Engineers held in Washington, D. C., January 23-24, 1925.

Now the engineer has been a busy person these last thirty or forty years during the time his profession came to dominate the land. He has not been willing to give much time or thought to matters of wider public interest, and he has allowed all sorts of other persons to dictate even the character of engineering, when it comes, at least, to public questions. Yet it is possible for those 200,000 trained and professional engineers, which we now have in America, to exert the dominant thought on these questions if they so will. And, if they did so, the whole approach to our public questions would be enormously modified—with facts. I do not say that in respect to solely national questions, for most of our problems are local problems, problems where the engineers of each locality should be on guard offering their advice and their influence that these things shall be rightly solved in the public interest.

When the engineer comes out into the middle of the mob and begins to express engineering thought, he will be subjected to a certain amount of discouragement. He will find a most blissful interchangeability of technical terms which the general public has grabbed from the engineer, and he will find himself, a large part of the time, trying to define terms to get precise thought.

I have been interested recently in reading some of our public statements where horsepower and kilowatt, where nitrates and nitrogen, have been used interchangeably throughout long debates. In fact, I have come to wonder whether some people know the difference between a cow and a kilowatt.

We hear the glib use of such terms as "superpower" and "giant power" in some hands dressed up in their poetic aspects, gigantic tendrils stretching throughout the land carrying the blessings of power in some new and undescribable fashion. On the other hand, we have them described as emanations solely from Wall Street. As a matter of fact, the engineer seldom uses those terms at all. But there is little that is poetic and there is nothing that is demagogic if we talk about central generation and interconnection. We do say what we mean and we understand our terms, but they are not terms upon which to base vast orations and, therefore, the engineer finds himself perhaps unduly depressed by the general rule of his profession which is to stick to precision of thought, to reality in terms.

Someone wrote a letter to me the other day and wanted to know why it was I had made some public statement as to the interconnection of power systems. The writer felt this was undoubtedly an emanation from Wall Street, that it gave a vast opportunity for further throttling of our nation at the hands of gigantic trusts dominated by malevolent men and, in endeavoring to reply to the general effect that the interconnection of our power systems was about, or fully, as important as the interconnection of our railways some seventy years ago, and that it had the same economic values as the interchange of cars has had in the transformation of our transportation, I received the reply, yes, that was the way the great trusts got control of the railways in the United States and we have not been able to shake them loose yet.

Yet, nevertheless, whether on the poetic side or on the demagogic side, the fact that the public is beginning to use terms which have even an indeterminate background is in itself evidence that the engineering view is at least in a small way penetrating public mind. If our engineers would be a little more vocal, if they would act a little more in the collective sense, if, instead of confining our activities to a single nationally developed Engineering Council, we could develop an Engineering Council for each municipality and each state that would stand on guard on all public questions—and I say all questions, for there are practically none today that have not engineering implications—we could transform the thought of this nation within another twenty years.

It is a service that can come to our country, with all its technical development, from no other quarter. It is a service that must be given in the public interest, if we would have it that this nation shall develop itself in its financial, in its industrial, and its broad economic relations, in such a fashion as to bring to our people the widest diffusion of those great blessings which the engineer grasps from science and brings to practical daily use amongst our people.

That is the plea; that the engineer might give thought in his organizations not entirely to the development of his profession, to the recounting of his technical and personal experience, but that associations of engineers should give thought in their discussions and public voice and their collective weight and influence to problems that are before our country which can be solved alone by the engineer's background in training and his method of thought.

We have one question today that very nearly concerns every electrical engineer in the United States. I would be willing to rest entirely upon the view of the electrical engineers on the question of public versus private ownership of public utilities. I would not pre-judge what the conclusion of the electrical engineers of the United States would be, but whatever it would be, it is an obligation of the engineers to formulate it and present it to the American people at this time. I have my own views, but I believe that no one individual's views have a right to dominate.

I would, however, be willing, and I believe our people would come to be willing, to accept the view of a profession as to such major and tremendous questions, and I believe it is possible, out of the organizations of our engineers as they stand today, to develop a proper consideration, proper thought, on problems of this character. I could enumerate a score of questions upon which no one can speak with the authority of the engineers at this moment, upon which none can speak with the consideration, with the vision, the imagination, with which you can speak. And yet we have had but little voice raised collectively from the engineers of America.

The engineer has a great purpose, a purpose far aside from his daily production. The very character of his profession is that of service and, in this character of service, it does not limit itself to the immediate problem which he has at hand; it carries with it an obligation to extend that service far beyond the limits of daily task.

The Business Situation

By **COL. LEONARD P. AYRES,**

Vice-President, The Cleveland Trust Company

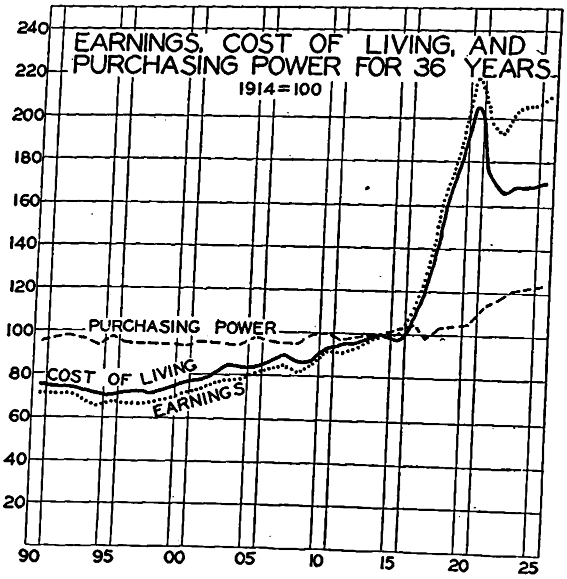
SOMETHING of a slowing down of business is inevitable during the next two months. The crops have been marketed. The holiday trade is behind us. Building construction is no longer so highly seasonal an industry as it used to be, but it is still true that there is much less building going on during the winter than in the other seasons of the year. A similar situation exists in the automobile industry. People use their cars nowadays all the year round, and many more cars are sold in the winter months than used to be the case, but nevertheless production, purchases, and use are at a lower ebb in the winter than at other seasons.

It is undoubtedly true that the maintenance of general business activity at anything like current levels during 1926 depends in large measure on the volume of building construction and the prosperity of the automobile industry, but it is also true that the output figures for these two industries in January and February cannot be used as a basis to estimate what they will do during the rest of the year. They both started off rather slowly in 1925, but by the end of the year both had made new high records for all time.

Real Wages

The typical American wage earner is better off than he has ever been before in the sense that his average earnings have increased in recent years more rapidly than the cost of living, so that a typical day's wage now buys more of the necessities of life than it ever has previously. The data on which these statements are made were presented at the recent winter meetings in New York of the national scientific associations. Thy were included in a paper by Professor Paul H. Douglas of the University of Chicago, who is about to publish them in a book on Real Wages in the United States.

The great prosperity of the American people at the present time is directly due to a large national increase in the real wages of employed workers in this country during the past five years. It is probable that real wages for the average employed worker are now about 23 per cent greater than they were just before the outbreak of the war in 1914.



The changes that have taken place in purchasing power, the cost of living, and dollar earnings during the past 36 years are represented by the three lines in the diagram. In each case the conditions existing in 1914 are taken as being represented by 100.

At present commodity prices are not much higher than they were four years ago, but wages are considerably higher than they were then. As a result purchasing power is large. Moreover there is little unemployment, and so prosperity is general. Fortunately it does not seem likely that there will be any drastic change in these conditions in the near future.

Iron and Steel

After a year of record making activities the iron and steel industry has entered 1926 with operations on a scale never before exceeded. Production of steel ingots is running at the estimated rate of 50,000,000 tons annually. Shipments are heavy, mill order books are well filled, and prices are holding firm. A good year seems to be ahead for the iron and steel industry.

Blast furnace operations have been increasing since July, and by the first of January the percentage of activity crossed above the theoretical normal line of 60 per cent. At the beginning of the new year there were 385 blast furnaces in the country, of which 234, or 60.8 per cent, were producing iron. The present prospects are that this percentage will increase during January, and it seems likely to continue to climb during the rest of the winter. The crossing of the blast furnace percentage above the theoretical normal level of 60 per cent has a special significance because it is one of the best indicators of general industrial activitiy, and because the experience of the past has indicated that the prices of most industrial stocks are likely to be in the selling range when the blast furnace line passes above 60, as it has just done.

One most interesting development in the iron and steel industry is to be found in the accumulating evidence that the country's requirements for steel are rapidly overtaking its productive capacity. No such condition had been looked for in the trade because it was assumed that there had been a great over-expansion during the war period which would not be caught up with for a long time. What seems to be happening is that open hearth furnaces, which use large percentages of scrap and facilitate the making of finer grades of steel, are rapidly rendering obsolete the Bessemer furnaces. During recent months large iron and steel companies have authorized the expenditure of more than $100,000,000 for the expansion of manufacturing facilities, and it seems likely that still greater expenditures of a similar sort will be authorized this year.

FROM THE NATIONAL CITY BANK OF NEW YORK

General Business Conditions and Outlook

The first month of 1926 has made a very satisfactory showing of business activity and prospects. The volume of trade continues large and reports from the industries are almost uniformly good, indeed generally optimistic. Car-loadings for the two weeks ended January 16, aggregated 1,843,774, against 1,866,829 in the corresponding weeks of 1925, but merchandise and miscellaneous loadings, which are the significant feature as regards the current trade movement, were 30,000 cars larger than last year. Unfilled orders of the United States Steel Corporation showed another increase in the month of December, for the fourth consecutive month, and all reports from the steel industry indicate that it is working close to capacity, with excellent prospects. The automobile industry reports advance orders by sales agents as giving promise of another good year. The railroads are budgeting for large capital expenditures. The building industry is starting off with more work planned than was in sight at this time last year.

The foregoing figures do not indicate the sort of conditions which usually precede a business reaction of some importance. The only reason why business ever should slacken is that it has a tendency to become unbalanced, which makes a slowing down necessary to enable it to recover its equilibrium. Price fluctuations are signs of a disturbance of the equilibrium.

We are not impressed with the reliability of calculations which foretell the course of the business cycle with exactitude, although the tendency of the volume of business to fluctuate cannot be disputed, and doubtless there is a tendency for fluctuations to repeat themselves as the result of similar conditions. The real cause of the disturbance in each instance, however, is a loss of the equilibrium which gives prosperity.

The most common cause of such a disturbance is slackening of construction work. Greater fluctuations occur in this class of expenditures than in any other, and it cannot be questioned that building operations have been an important factor in the industrial activity of the last several years. The question is whether it is possible to foretell with any close degree of accuracy when this period of building activity will end. We think few would have dared at the beginning of 1925 to predict that the year would end with more work in sight than there was at the beginning. Persons of experience are now saying that this period of building activity is unlike any preceding one, in that never before had there been so great a change in the class of habitations wanted. They say that the present demand for houses is not simply to provide for an increase of population, but to meet a general demand for a different class of habitation, and that the new houses will be built and occupied even though the old ones are abandoned. How far this demand will go remains to be seen, but the end does not appear to be in sight.

The F. W. Dodge Corporation has estimated the total amount of building expenditures in the country in 1925 at $6,600,000,000. These figures to the extent of nearly $6,000,000,000 are based upon actual contracts, the remainder being an estimate for unreported work.

Signs of Industrial Stability

The encouraging feature of the situation is the stability which has been maintained in prices throughout the past year. While rising prices are a hopeful sign when industry is recovering from a period of depression, they become a menacing sign when they signify credit and price inflation. Now that the Fall and holiday rush of business is over and an opportunity is afforded to compare the volume of commercial loans at the middle of January, 1926, with the volume at the corresponding time of 1925, it is interesting to find that the increase has been very slight. Excluding loans secured by stocks and bonds, the greater part of which represent purchases of stocks and bonds or investments outside of regular trade and industry, the loans of reporting member banks in January, 1926, aggregated $8,321,081,000, against $8,244,685,000 on January 14, 1925, an increase of only $86,000,000. As nearly as can be arrived at by banking statistics now available, that is about the sum of the absorption of bank credit by the regular business of the country in 1925.

The record of prices is in accord with this record of credit expansion for business purposes. The Bureau of Labor table of index numbers, representing the prices of 404 commodities, using 1913 prices as the base, show a composite index number for the month of December, 1925, of 156.2, against 157 for the month of December, 1924.

Items of Interest

DEPARTMENT OF COMMERCE
WASHINGTON

National Committee On Metal Utilization

William Chattin Wetherill, who is on leave of absence from the Department of Mechanical Engineering of the University of Pennsylvania, is the director of the National Committee on the Utilization of Metals. The committee is first concerning itself with furthering the application of the principle of simplified practice, and the director is at work on the development of a method of securing the adoption throughout the metals industries of simplified practice recommendations already approved by a group or groups. Success in this cross-acceptance program will lead to a National Directory of Simplified Commodities which will be an aid to designers, purchasing agents, and the general public.

In addition to the work of spreading the work of simplified practice and securing its cross-acceptance, the simplification of specifications for metal products is being studied. This study is based on the publication by the Bureau of Standards of the National Directory of Commodity Specifications, containing a list of more than 27,000 specifications for approximately 7,000 commodities. The diversity in commodity specifications as shown by this directory points to the elimination of unnecessary differences, with a consequent reduction in waste.

At a meeting with Secretary of Commerce Hoover on January 26th under the auspices of the National Committee on Metals Utilization, members of the steel reinforcing bar industry took initial steps looking toward the reduction of the existing variations in specifications for steel reinforcing bars. This meeting, containing representatives of rolling mills, consumers, distributors, technical bodies and other interested organizations, after an extended debate, adopted a resolution asking that a committee be appointed by the Department of Commerce to survey, through the proper channels of production, distribution and consumption, what grade or grades of new billet concrete reinforcing steel are most desirable. This committee is asked, under the terms of this motion, to conduct a referendum among users, distributors and producers, and to report at a general conference to be held soon after October 1.

Prof. Wetherill, who presided, at the outset of the meeting, read communications from a number of representative distributors and users endorsing the proposal for simplifying the specifications. A. E. Lindau, chairman of the committee of the Concrete Reinforcing Steel Institute, on grades of reinforcing steel and standard sizes outlined the position of the Institute. He declared that the simplification of specifications offers a potential saving of $5,000,000, a year to the construction industry. He reviewed the development of reinforced concrete construction and its rapid growth in urban areas where storage space for materials and where handling present serious difficulties. The business handled through distributors, he said, now amounts to more than the entire consumption of 20 years ago, while the total use of steel reinforcement has multiplied itself from 80,000 tons a year to 700,000 tons a year.

Corrosion in Boilers

A study of the mechanism of corrosion and the factors effective in its control in steam power plant operation is being conducted by the Bureau of Mines, Department of Commerce, at its Pittsburgh, Pa. experiment station. The purpose of this investigation is to obtain data on the amount of hydrogen concentration that should be maintained in the boiler water in order to reduce corrosion to a negligible proportion. In economizer tubes and feed lines especially, dissolved oxygen in the water causes a great deal of corrosion. Elimination of dissolved oxygen can be partly effected by deaeration, but this does not wholly remove the oxygen. If the hydroxyl concentration can be controlled to suit the conditions, it can be utilized to control the oxygen.

Gas Plant Tests

A series of gas plant tests, designed to obtain information in regard to the proposed gas plant testing code of the American Gas Association, will be made by the Bureau of Mines in cooperation with the Association. Arrangement has been made by the American Gas Association for six plants in the East to operate for approximately one month each using exactly the same coal. During this operation complete records will be kept of all measurable quantities involved in the plant operation, so as to obtain the productive and thermal efficiencies of each stage and of the plant as a whole.

Another phase of this investigation is to determine the characteristics of the cokes produced in the cooperative tests with the gas association, from the same coal by six different types of coking furnaces. All the physical and chemical properties of these cokes will be measured following the specifications of the American Society for Testing Materials where such have been formulated. Also standard and special combustibility tests will be made, as well as a special test of the suitability of the cokes for use in household furnaces.

Heat Flow Meters for Furnace Walls

A study of heat flow meters for furnace walls is being conducted by the Bureau of Mines, Department of Commerce. The purpose is to develop meters for the measurement of heat flow from kiln walls, boiler settings, surfaces of coal in mines, and similar problems. Seven meters have been constructed, 2 ft. square and about 3/22 inch thick, and have been partly calibrated by passing known rates of heat flow through them. When the calibration has been completed they will be available for special investigations on the flow of heat through refractory walls and for obtaining a measure of the radiation from boilers, kilns, etc., during an efficiency test.

Modifications of the Orsat Apparatus

Many modifications of the original Orsat apparatus for gas analysis are in use at present, each having its merits and being particularly adapted for some special line of work, the Bureau points out. The number and the kind of pipettes used depend on the composition of the gas to be analyzed. If ethane is to be determined, in a complex gas mixture containing carbon monoxide, hydrogen, methane and ethane, a copper oxide tube is used for combustion of the hydrogen and carbon monoxide and the cuprous chloride pipettes may be omitted to advantage. If ethane is absent, as in producer and blast-furnace gases, two cuprous chloride pipettes may be used to absorb the carbon monoxide and the copper oxide tube may be omitted.

With the apparatus used in the Bureau of Mines gas laboratory at Pittsburgh, Pa., for the complete and partial analysis of gases, a complete analysis—including carbon dioxide, illuminants, oxygen, carbon monoxide, hydrogen, methane, and ethane—can be made without connecting or disconnecting any parts. Since all other constituents are removed before the paraffin hydrocarbons are burned, larger amounts of the paraffine may be often taken for combustion with oxygen, and more accurate determinations of methane and ethane can thus be obtained. The same argument holds true for hydrogen and carbon monoxide, which are determined by fractional combustion with copper oxide at 300°C. Either mercury or water may be used as the confining liquid in the burette, depending on the accuracy desired.

As the Bureau of Mines has received many inquiries regarding gas-analysis methods used in its laboratories, this description of the Orsat apparatus it now uses is published in response to those inquiries.

Copies of Technical Paper 320, "The Bureau of Mines Orsat Apparatus for Gas Analysis" by A. C. Fieldner, G. W. Jones, and W. F. Holbrook, may be obtained from the Bureau of Mines, Department of Commerce, Washington, D. C.

High Points of Annual Meeting, American Engineering Council

January 13-15, 1926

Government in Industry

The Council had been invited to become an affiliated member of the Conference on Government in Industry. This it declined to do. However, it voted to lend its moral support to the purposes of the Conference. This it did by declaring it to be the sense of American Engineering Council that the Government should not trespass upon the field of industry unless it was satisfactorily shown that the Government could better engage in a particular business than private enterprises.

Federal Power Commission

In view of the fact that bills have been introduced into Congress proposing to remove the Tennessee and Colorado Rivers from the jurisdiction of the Federal Power Commission and since other legislation is pending which, if passed, will undermine the Commission, the Assembly approved a resolution of disapproval of all such legislation. The Assembly instructed its Water Power Committee and officers to use all possible means to defeat any legislation that tends to impare the usefulness of the Commission or to destroy the functions thereof as provided for in the enabling act.

Patents

The Assembly unanimously endorsed House Bill 3831 "A bill to increase the salaries of Federal Judges," and instructed its Patents Committee to exert its efforts to secure the passage thereof.

The Assembly also passed a resolution authorizing its officers to aggressively endeavor to secure a new building for the Patent Office. They were instructed to enlist the active support of all interested groups. The urgent need for a new building and modern equipment was clearly set forth by the Executive Secretary, who has been serving on a Committee on Patent Office Procedure, appointed by the Secretary of the Interior and continued by the Secretary of Commerce.

Street and Highway Safety

Mr. W. B. Powell, Chairman of the Committee on Street and Highway Safety, submitted a most suggestive report. The committee recommended that American Engineering Council alone or in co-operation with other organizations have a study made of:

A Traffic control signals.

B Directional and general traffic signs for city streets.

C Analysis of the physical factors entering into the efficient operation of street intersections.

D Analysis of the most efficient methods of turns at intersections.

The Assembly approved the report and referred it to the Administrative Board for consideration of ways and means to have the study made.

Department of Public Works and Domain

The Conference on Public Works was attended by official representatives from sixty-three engineering and allied technical associations. The conference approved the draft of a bill providing that the Department of the Interior be named the Department of Public Works and Domain. The drafted bill calls for the following four assistant secretaries: an assistant secretary having administrative jurisdiction over the Design and Supervision of Architectural Works; an assistant secretary having administrative jurisdiction over the Design and Supervision of Engineering Works; an assistant secretary having administrative jurisdiction over the administration and execution of the Construction Work of the Department of Public Works and Domain; and an assistant secretary having administrative jurisdiction over the Public Domain. Under the provisions of the bill all subdivisions of the Federal Government of an architectural, engineering and construction character would be transferred to the Department of Public Works and Domain.

The Bill will be introduced in the Senate by Senator Jones of Washington and in the House of Representative by Congressman Wyant of Pennsylvania.

Program of Research

Dr. H. E. Howe, Chairman of the Committee on a Five-Year-Program of Research, presented a progress report which was enthusiastically adopted. This program proposes the following studies:

Waste in Agriculture with special reference to the engineering phases thereof.

Survey of Waste in Industries using Agricultural Products as Raw Materials.

Waste of Power in the realm of generation, transmission and use of power obtained from coal, oil and gas.

Reclamation of Material Wastes such as metals, forest products, city refuse and garbage.

The Engineering Approach to the Problem of Labor Supply.

Training and Employment of the Partially incapacitated.

Industrial Fatigue.

Integration of Industry.

This program contemplates the expenditure of approximately $350,000 during the next five years.

On the basis of past experience and a known source of interest, it is believed the necessary funds can be secured.

Survey for 1926

The Council has secured $25,000 with which to defray the expense of its survey for 1926. This survey will have to do with safety in industry. The details are being developed and a further announcement concerning it will be made in the near future.

Officers

Dean Dexter S. Kimball, of Cornell University, was elected president.

The Vice-Presidents are:

Gardner S. Williams, Ann Arbor, Michigan.

O. H. Koch, Dallas, Texas.

I. E. Moultrop, Boston, Massachusetts.

A. W. Berresford, New York City.

Dr. H. E. Howe, Washington, D. C., was re-elected Treasurer, and Colonel John H. Finney of Washington, Chairman of the Finance Committee.

L. W. Wallace was again elected Executive Secretary.

Timber Resources of British Guiana

Structural Tropical Woods—Their Advantages and Drawbacks

By LLOYD T. EMORY
Consulting Engineer, Philadelphia, Pa.

WITH the exhaustion of the American and Canadian timber resources in the not too distant future, it becomes necessary for engineers to look elsewhere for materials of construction. The South American forests offer certain possibilities in the way of tropical woods that have decided advantages for special purposes and that could be used by engineers where prices on large sizes and long timbers have risen to the point that would enable the paying of the extra cost of transportation.

This article deals with the woods of British Guiana, which is the only Colony of Great Britain on the South American Continent, and is readily accessible to steamers and sailing vessels from the Gulf and Atlantic ports.

British Guiana has an area of 89,480 square miles, 86% is covered with forests,[1] 90% of which are probably virgin as only timber along the lower reaches of the navigable streams has been cut. Practically all of the interior is Crown (Government) Land, which can be leased on easy terms on a royalty basis.

The Colony consists of three belts—a coastal plain, a broken mountainous region and an upland plateau. The variety of timbers found varies not only with the distance from the coast, but also with the valleys of the different rivers. As the Colony reaches from one to eight degrees north latitude, the climate is tropical and with an abundance of rainfall is ideal for forest growth. As it is outside of the hurricane belt, the lumber is free from the many defects caused by high winds.

While there are twenty-five or thirty varieties of wood that have commercial possibilities, only the five considered of most importance for structural purposes will be described in detail. The names in most cases are derived from the aboriginal Indian nomenclature and have been adopted by the local, or British Guiana Forestry Department.[2]

Greenheart is probably the best known British Guiana wood outside of the Colony, and has been exported in considerable quantities for over a hundred years to Europe.[3] It is rated as one of the eight first-class woods by "Lloyds" and is used extensively locally for shipbuilding and in foreign ports for submerged work such as wharves, docks and lock gates, etc. It was used in the construction of Nansen's Arctic ship the "Fram" and of the "Discovery" of Antarctic fame. The dock gates in the Mersey Harbor and the 50 lock gates of the Manchester Ship Canal[4] are built of this wood.

Owing to its teredo resisting qualities and the fact that logs can be obtained that will square from 10 to 25 inches, up to 65 feet in length, it is especially adapted for dock work in salt or brackish water.

The wood is used quite extensively for both framing and weather-boarding locally, owing to its resistance to wood ants which are very destructive. This resistance to the attack of insects is attributed to the presence in the wood of an alkaloid known as biberine and of a resinous substance known as tyloses.[5]

The wood when freshly sawed is of a light yellow color with a greenish tinge. It is compact in structure, having a specific gravity of 1.143, weight per cu. ft. of 71 pounds, tensile strength of 8,960 pounds per sq. inch, and a crushing strength of 14,200 pounds per sq. inch.[6] It saws easily and turns or machines well.

Mora (*Demorphandra Mora*) is also listed among the eight best construction woods by "Lloyds." It is of a reddish tinge in color and owing to a gummy substance which exudes during sawing is rather difficult to work.

Locally it is used for railway ties, piles in fresh water, caps, beams, guards and decking on wharves, ship frames, guards and planking above the water line, also for house frames and weather-boarding and is very resistant to dry rot. It has a specific gravity from 0.87 to 1.10, weight per cu. ft. of 67 pounds, tensile strength 11,060 pounds per square inch, a crushing strength of 9,980 pounds per sq. inch.[7]

It will work well under a planer when properly seasoned, but turns poorly. Trees often grow to the height of 200 ft., but such old specimens are usually hollow. Sound logs that square 24 inches are obtainable.

Crabwood (*Carapa Guianensis*) or British Guiana Mahogany as it is sometimes called, resembles mahogany very much in texture and appearance when finished and is often used as a substitute. In the unfinished state it looks very much like Spanish Cedar, but is harder. Logs up to 60 feet in length and squaring 16 inches can be obtained. Exceptionally large trees have been known to reach the height of 170 feet with a diameter of 42 inches. It is essentially a finish wood for interior work and furniture, but is sometimes used locally as weather-boarding and is resistive to insects.

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[1] Forests of British Guiana, General Report. Pub. in 1912, by W. Wilgen Anderson, Forestry Officer.

[2] Our Forests, by L. S. Hohenkerk, Forestry Officer. Journal of the Board of Agriculture, January, 1923.

[3] Timbers of British Guiana, by Sir Robert Schomburgh, published in October, 1844.

[4] Engineering (London) for August 29, 1890.

[5] U. S. Dept. of Agriculture, Forest Service Circular 211, by C. D. Mell.

[6] Molesworth's Pocket-Book.

[7] Report of tests of B. G. Woods Forest Products Laboratories of Canada, August 29, 1918.

It has a specific gravity from 0.47 to 0.70, weight from 38 to 46 pounds per cu. ft., tensile strength 9,760 pounds per sq. inch and a crushing strength of 8,980 pounds per sq. inch.

It planes easily, turns and polishes, which makes it valuable as a cabinet wood.

Wallaba (*Esperua Sp.*) when freshly cut has a deep red color which darkens on exposure. In the green state it exudes a red sap that smells and tastes somewhat like creosote.

Locally, it is used for house frames, fence, telegraph and other posts, vat staves, shingles and railway ties. It is burned to charcoal for local use and export.

It has a specific gravity from 0.99 to 1.02, average weight of 65 pounds per cu. ft.

It splits easily in making shingles or staves, planes fairly well and turns in a hand machine, but not in a power lathe.

Both the local railway and the street car lines in Georgetown use it quite extensively as ties, but owing to its tendency to split, spike or bolt-holes have to be bored. Trees of this timber average 80 feet in height and logs squaring 20 inches are obtainable.

Determa (*Nectandra Sp.*) in pinkish red, although sometimes of a salmon color, with a well defined sap wood of a dirty white.

It is used locally for weather-boarding, boat-planking and spars, and almost anywhere that a light strong wood is required.

It has specific gravity around 0.57, average weight of 39 pounds per cu. ft., tensile strength 5,580 pounds per sq. inch and crushing strength of 5,660 pounds per sq. inch. Trees have an average height of 100 ft. and logs squaring up to 30 inches are obtainable.

It saws and planes easily and can be used for almost any kind of construction, if proper precautions are taken to protect it from the weather and insects.

On the navigable reaches of the rivers below the first falls or rapids the best timber has been cut back for two or three miles from the river bank. However, large tracts are easily within the reach of narrow gauge logging roads.

Owing to the high specific gravity of the principal woods, it is impossible to float them without support. They have to be either made into rafts with lighter woods or supported alongside of punts or scows. This feature has one advantage, however; timber can easily be stored in shallow, fresh waters as, once it rests on the bottom, it stays there and is safe from dry rot and insects.

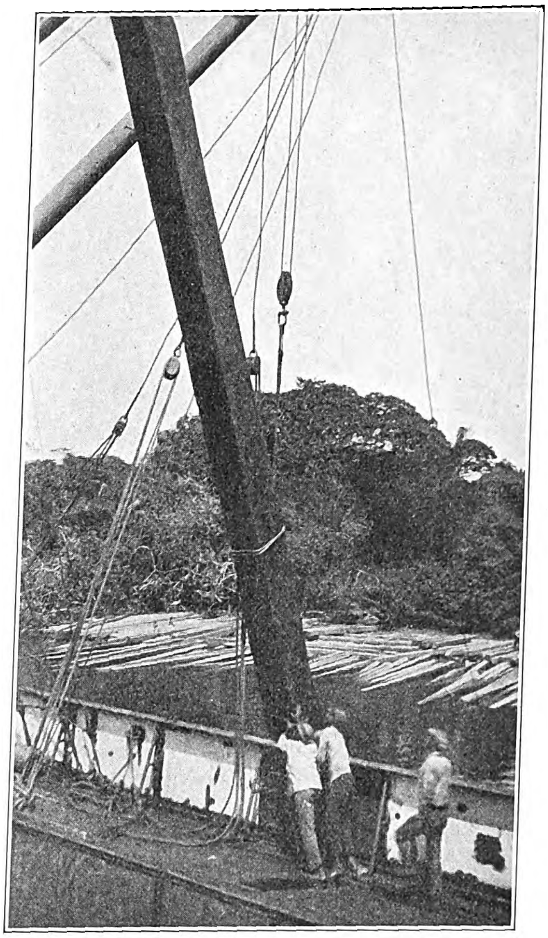

Photo by L. S. Hohenkerk, Forestry Officer, British Guiana.

Hoisting Log Aboard a Steamer
Timber Storage Flat in Background

Most of the rivers have long stretches of navigable water above the first rapids where virgin timber grows at the water's edge, but an operation must be of such magnitude as to justify the building of a railway or skid-way around these obstructions.

The Crown (Government) Land Regulations[8] provide for leases for long periods under special terms. Several twenty-one-year leases have recently been granted on the following terms:

Rent free for the first year and an annual rental of one cent per acre thereafter.

Royalty to be paid on all timber cut at the schedule of rates published in the Regulations, but in no year shall the total amount of royalty paid be smaller than the sum of 50 cents for every hundred acres leased, or the difference between the royalty and such sum to be paid by the lessee.

The Lessee within three years is required to erect and thereafter maintain a fully equipped power-driven sawmill plant on, or for the purpose of sawing timber from, the property.

While there is not a great surplus of labor in the Colony, little difficulty need be experienced in mobiliz-

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[8] Obtainable from the Commissioner of Lands and Mines at Georgetown, British Guiana.

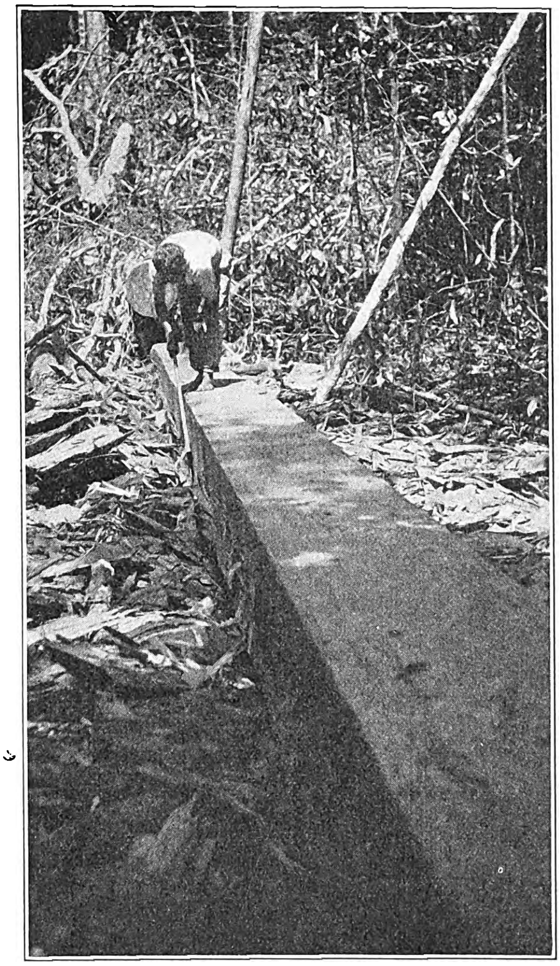

Photo by L. S. Hohenkerk, Forestry Officer, British Guiana.

Squaring the Log With Broad-Axe

ing a labor force up to a thousand men for a new proposition.

Cutting and squaring in the bush is usually done by aboriginal Indians from tribes near at hand; transportation and saw-mill work is performed by negroes. While labor is not as efficient as in northern climates, if proper food in sufficient quantities is furnished, sanitation carefully looked after in bush camps and medical attendance supplied, very fair results can be obtained, especially if pay can be arranged on a piece-work basis.

In order to reduce the weight as much as possible because of the crude methods of transportation, it has been the custom to rough square logs where the tree is cut. Most of the "export timber" at present is squared by hand with a broad-axe.

The principal mills now operating are located on the water front at Georgetown and buy their supply of raw material from small grant-holders.

The question of type of mill like that of mode of transportation is a debatable one, and a selection should not be made without first carefully studying the characteristics of the woods, local conditions and the type and intelligence of labor used as operatives. The circular saw, either with solid or inserted teeth, has not proved satisfactory, as a number of the timbers tend to split when sawn at high speed. Gumming also has to be overcome, as it adds considerably to the heating of the saw.

The writer installed and used successfully a band saw having a capacity of 10,000 board feet per day, where lumber was required on the ground for the construction of a mining town. However, a sawyer and sawsetter had to be imported from a hardwood mill in the States and not having spares left us in a rather difficult position. The local custom of cutting logs of long lengths, except in special cases, had to be abandoned and a maximum length of 20 feet adopted.

The log frame saw is used almost entirely locally, and performs quite well with the type of labor available. It, however, has its limitations in speed and economy of timber. With a circular or band saw, if a defect is discovered it can be cut out with the minimum of loss while, with a frame saw set for given widths, the log may be sawed through to the end without discovering the fault.

Anyone considering starting operations in the Colony should make a very careful study of local conditions to ascertain why certain equipment is in use before attempting to introduce new machinery no matter how successfully it has proven elsewhere.

Several attempts have been made during the past fifteen years by American capital to exploit the Guiana forests on an extensive scale, but each ended in failure, due, in the writer's opinion, to faulty management or lack of sufficient funds at critical times. Anyone entering the field should have had not only lumbering experience elsewhere but also breadth of vision and sufficient openness of mind to adapt his knowledge to both new conditions and new material.

The importance of tropical sanitation should never be forgotten. People from a northern climate should eat, drink and work in moderation.

The facts that the English language is spoken in the Colony, dollar currency in circulation and Law Courts that are beyond reproach available, make the field an attractive one for investment.

Research and Its Application to Engineering*

By GEORGE A. HOADLEY, D. Sc.
Swarthmore, Pa.

EVERY normal child has the spirit of research born in him. His first attempt to reach out and grasp things, whether it be the edge of his cradle or the moon that he sees shining through the window, is a search for something he does not know about, but about which he wants to learn. If he does not find out at the first effort he tries again and so his search becomes a research.

Practically all we know about material things has been found out through the persistent research of those who have preceded us.

Nor have men been content to deal with material things alone, for many years ago one of the sages of his time, having given much of his life to research in spiritual things, asks the question that has not yet been answered "Can'st thou by scearching find out God?" If this can ever be answered in the affirmative it will be because the master key of the universe has been found.

Still, if he could not claim success in his search he must have known that he was much the better off for having made it. In fact one of the compensations for the research worker is that even if what is sought is not found the reaction upon himself is an increase in intellectual vigor and a fuller understanding of the phenomena of the problem which he is trying to solve.

What may be termed modern research had its beginning within the memory of many of us. At first it was purely scientific research undertaken by teachers in schools, colleges and universities who became interested in the phenomena that are the basis of physical and chemical law and in order to become better teachers and to be able to explain to their students the HOW of the operation of these phenomena, they set themselves to work to ask questions of Nature and through definite experiments, under known conditions, to find her answer.

The work which was carried on by these teachers laid the foundation for what has become a national industrial necessity and for this work they were looked upon by the world at large as probably being deficient in some of their mental faculties and for compensation they received yearly salaries that would be looked upon with scorn if offered to one of our modern workmen as wages for a couple of months.

Early research was practically all along scientific lines, a seeking after truth for its own sake with no thought of the application of what was found to industrial uses. It was soon found, however, that the results obtained in these researches could be applied in a practical way and every branch of scientific knowledge has been greatly enriched by such applications. One has only to name the workers in scientific research to appreciate how great a debt of gratitude is due them for what they have given to the world.

The Phenomena of Life.

Workers in the biological sciences have been greatly interested in the phenomena of life, particularly in the development of life in its early stages. Naturally this interest has led them to give especial attention to the biological enemies of life, that is to diseases of biological origin and while they have made especial studies of guinea pigs and white rats these studies have only been for the purpose of getting information for the benefit of mankind. As a result many of the diseases that were veritable scourges to humanity have been controlled and cures have been found for some of the most deadly.

Smallpox, that formerly disfigured or killed people by the thousands, is now readily avoided. Diphtheria, that scourge of childhood a few years since, has been conquered and the same can be said of typhoid fever. Not only have these diseases been controlled and their cures found, but in many cases their causes have been found and we have been taught how to avoid them.

All this has come about through researches that have been carried on during the lifetime of most of us who are here.

The results of biological research have been of great benefit to the engineer by showing him how to avoid disease. The building of the Panama Canal was made possible through the research that proved that a certain type of mosquito was the carrier of the germs of yellow fever. This discovery, followed by the destruction of their breeding places, swept yellow fever out of existence as a pestilence and as a factor in the Canal Zone and made possible for American engineers the completion of a work of international importance.

Research Broadens Outlook.

One of the valuable features of research is that it broadens ones outlook on nature and physical life. Studies with the ultra miscroscope have enabled us to gain information of beings almost infinitely small and the use of the telescope brings to our knowledge such immensities of distance, dimension and time that we can form no conception of their meaning. We have become accustomed to speaking of these great distances, but we have nothing with which to compare them. We say glibly that the sun is, in round numbers, 93,000,000 miles from the earth. We think of an airplane as a rapid means of travel. Let us board our plane and take a trip to the sun. If we make a non-stop flight at the rate of 200 miles per hour we shall reach the sun, in fifty-three days? No, in fifty-three years. Yet a beam of light takes only 8 minutes and 18 seconds to make the same trip, but it moves at a rate of 188,000 miles per second. Such is the immensity of distance that the astronomer deals with, that he uses for a foot rule, for the measurement of distances to the fixed stars, the distance that light would pass over in a year and calls it a light year. Then he tells us that if some one of these outer sentinal stars had been blotted out of existence at the beginning of the Christian era the light that it sent out then would not yet have reached us—we would not know that it had been blotted out. Not content with that he tells us that the light from some of the more distant fixed stars requires many thousands of light years to come from them to us. It is just because they are so far away that, though they are moving with great velocity, they appear to be fixed and give to the civil engineer a means of finding the latitude and longitude of places on the earth. Even this earth of ours is not standing exactly still, for since we came into this room an hour ago we have moved over 66,000 miles in our journey around the sun.

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*Address before The Engineers Club, Philadelphia, Pa., January 26, 1926.

Researches in the physical and chemical sciences have possibly been brought closer to the work of the engineer than have those in the other sciences, mainly through the fact that they have to do with forces and their application to material bodies. Such researches have dealt both with the forces in nature and with those furnished and controlled by man. These researches have also dealt with the materials of nature.

Iron is one of our most useful metals and widely distributed in its natural state as an ore, but it has taken years of patient study for the chemist to determine the proportion of its combination with carbon that will change it into steel and with different metals to give to the engineer a steel so modified as to have just the qualities that are of most value for the various uses to which he wishes to apply it.

The steel tool used in a lathe to turn down a steel shaft to the required size must have a different grade of hardness and toughness from that used for the shaft. The steel used in the making of a good pocket or carving knife must be quite different from that used in a fence nail and to meet the most modern requirements it must be stainless. When it is considered that each of the required qualities has been secured only after prolonged research and many tests of results by the physicist, the chemist and the metallurgist, the value to the engineer of research along this particular line becomes self-evident.

The Fruits of Research.

We have here in Philadelphia a notable example of the fruits of research in the new bridge that connects this city with Camden. In its design and in many of its details it differs from existing bridges. It could be designed to carry its vertical loads, that is, the dead weight of the structure and the normal load it is expected to carry, from data already known, but the increasing number and speed of automobiles with their resulting thrust, brought in an unknown factor that had to be taken into the account. Data for the wind thrust upon the bridge and its towers were already on hand, but the possibility of a heavy airplane striking against the top of one of these towers brought up an unexpected problem that needed to be taken into consideration.

The most thorough and painstaking research had to be carried on regarding the durability of the materials that went into its construction, tests of the tensile strength of the wires used to make the cables and of the best form of joints by which they were to be connected, had to be made by the engineers so that they might know without the possibility of question that this bridge can safely do the work for which it is built and that it will stand for many years as a lasting bond of union between these two adjoining states.

X-Ray.

The discovery, thirty years ago, of an invisible radiation, hitherto unknown, to which the discoverer gave the name of the X, that is the Unknown Ray, has placed in the hands of the worker in physical research a tool of many uses, only a part of which are yet known.

The astonishing announcement that a new kind of radiation had been discovered by means of which bodies opaque to light, proved to be transparent, to a degree differing with the kind of material of which they were made, quite properly created a sensation in the minds of scientific men that will never be forgotten by those who heard it at the time.

Its immediate effect was to set men searching the dust-covered upper shelves of physical laboratories for various forms of Crooke's tubes, some of which were found capable of giving out these rays and from that time, instead of being used for demonstration only once a year, they were pressed into active service as tools for research in a new field.

Any man who ever made a radiograph of a boy's hand and saw the bony structure stand out distinct from the fleshly covering recognized at once that an invaluable tool had been placed in the hands of the surgeon, that would give him exact information about broken bones and bodily conditions and provide means for making a surgical operation no longer a matter of skillful guesswork, but an application of accurate information.

The progressive improvements that have been made in X-Ray tubes in the last quarter of a century and in the application of the X-Ray to the solution of research problems, forms one of the most interesting chapters in the history of scientific research.

The results have been successfully applied to industrial research to such an extent that the engineer does not need to run the risk of using a defective iron casting in a responsible position but can determine beforehand by X-Ray examination whether or not it is of uniform structure and suitable for use.

It is in such ways as this that the results of scientific research lend themselves to the solution of engineering problems and the removal of difficulties.

Essential in Construction Work.

It is most important in construction work for the engineer to know how the strains are distributed in the metal parts of a structure in order to provide parts of such a shape and size that they can stand up under the stresses to be placed upon them. This informatin can be found by making models of the parts in some transparent material and examining them in the polariscope. When the stress is applied dark shadows will appear in the polarized light passing through the model and the distribution of these shadows will show where the strain is greatest and form a basis for whatever changes are needed in the part.

When Dalton conceived the idea that matter is made up of minute molecules and their still more minute divisions, the atoms, he placed before the minds of the chemist a new conception of matter.

Following out this idea, the old-fashioned chemist, being furnished with suitable glassware, a pair of accurate balances and a readily controlled source of heat, was able gradually to make new combinations of these molecules and atoms and to give to the world new and unknown substances.

So great have been the changes brought about by the researches in chemistry that a whole new line of industries have sprung up to manufacture the new things that have been devised. It may also be added that so great has become the demand that the company that does not employ research in the development of its products is headed straight for bankruptcy.

The Atom.

Having made such a satisfactory use of the Dalton unit, the atom, it seems somewhat ungrateful that the physicist and chemist should join forces to prove that it is not really the ultimate unit of matter. That it is, in fact, a very complex thing, much like our solar system.

According to the latest reports the atom has a nucleus which is positively charged, or is a positive charge of electricity. Around this nucleus there revolve in orbite, circular, elliptical or otherwise, electrons, negative charges of electricity which when content to revolve in a single orbit, even at a high rate of velocity give off no light waves but when they jump from one orbit to another, give off a flash of light that will register in the spectrometer as a certain wave length, one which serves to identify the element of which this electron is a part.

For the sake of the engineer I am glad that these electrons, with ceaseless revolution, are so small that we shall never know by our senses that they are in motion and that the stars are so far away that we shall never see that they are moving. Our failure in these directions gives us a certain feeling of stability that is reassuring.

Apparatus and Training.

As has been said the early chemist worked with little and simple apparatus. That is not the case with the chemist or chemical researcher of today. He wants an abundance of apparatus and that of the most recent construction. He also wants great buildings with rooms specially constructed for the work to be done. He no longer works alone and in seclusion and his number is increasing every day. It is on this account that one of the serious problems that confronts research in both pure and applied science is how to be supplied with properly prepared young men and women who are sufficiently interested in work of this character to devote their most active years to its pursuit.

The present industrial situation is such that a young man who has been graduated from a scientific or engineering course in college, instead of having to make a long and sometimes fruitless search for something to do for which he is qualified, has presented to him, even before he is graduated, a number of positions from which he can make his choice. It is unfortunate, but probably true, that his choice is too frequently based on the amount of his prospective salary rather than on his qualifications for the work.

I believe there is a greater need at the present time for research workers in pure science than for those in its industrial applications. My reason for this belief is because the research worker in science is searching for truth, the fundamental basis for all knowledge, the foundation for all real advancement. He is like the mathematician who works out a general formula that is applicable to an entire group of problems, while the worker in industrial research is like one who applies the general principles of this formula to a specific problem and by making such modifications as are required by the conditions, obtains the correct solution.

That the discoveries of research in pure science form the basis of extensive future applications can be shown by many examples. Faraday was assuredly interested in his researches solely on account of their scientific bearing and felt no concern about the application of what he discovered, yet his discovery of electro-magnetic induction led to its application in electric machinery and was the basis of many of the practical applications of electricity that fill so great a place in our every day life.

When Sir Humphrey Davy was experimenting with an electric battery of many cells, he put together the ends of two wires that were joined to the terminals of the battery and noticed that when he separated them there was, for an instant, a brilliant spark.

On fastening small pencils of charcoal to the ends of the wires and repeating the experiment he found that a persistent brilliant light was the result. He had discovered the arc light. The developments of that simple experiment have given to the world an important source of illumination. When we trace by night the beam thrown by a powerful search light projector far into the sky, do we ever think of the early research that gave it birth?

Research vs. Industry.

The problem of supplying research workers, that is, of properly preparing them for the work, is one that the colleges and technical schools must take seriously to heart. A large per cent of the present day undergraduates have no adequate idea of what they want to do after graduation. Being without a set purpose they are in just the condition best suited to learn the advantages of work in scientific research and this should be shown them by their instructors.

It has too often happened that when a young man has shown by his work in scientific research in an institution that he has ability and initiative, he is lured away by some industrial company that by means of the length of its purse can make his salary more attractive than can the college.

The average college is not a money making institution while the industrial concern that employs research sometimes is and that is one reason why the greater salary can be paid and also why the colleges should be so endowed that they can meet this kind of competition.

That this competition will increase rather than diminish is shown by the extension of industrial research. A few years ago the National Research Council published a list of over 500 industrial laboratories in which 5,000 workers in physics and chemistry were employed.

There can be no question that the list has largely increased since the time of that publication.

Before the days of research the favorite method of deciding what results would follow from certain causes, was through a course of philosophic reasoning. When this was applied to the results of forces acting upon material bodies, it was called Natural Philosophy and the results thus reasoned out were either confirmed or disproved by observation. A noted discussion was the one over the question "Which will fall the most rapidly, a one pound weight or a five pound weight?"

They knew of the mutual attraction between the earth and a body on or above its surface and many of them reasoned that since the attraction between the earth and the heavier body was the greater that body would fall faster than the lighter one. Then, someone suggested that they could find out by a trial and so they took the two weights to the top of the leaning tower in Pisa and on being dropped at the same time they struck the ground together. This result was explained by the fact that while the attraction for the heavier body was five times that for the lighter, it had to move five times as great a mass and hence its rate of fall was the same. Not only did this experiment answer the question but it stopped all discussion, a result that knowledge of the facts in the case frequently has.

In spite of what has been learned through research there is collossal ignorance concerning much that is fundamental. One of the forces concerning which we know very little is attraction. We give it a name and say that because of this force acting through almost infinitely small distances and between the molecules of matter bodies retain their forms. We separate this force into two, calling that acting between like molecules, cohesion and that between unlike molecules, adhesion but we have added nothing to our knowledge regarding these forces, we have simply increased the number of names.

Then, there is a form of attraction that acts between bodies of matter and this we call gravitation. To the special attraction between the earth and bodies on or near its surface we give a special name and call it gravity.

What would be the result if molecular attraction should cease for an instant? Why every physical body, the earth and all bodies on its surface would instantly change into an impalpable powder. Suppose that both molecular attraction and gravity should cease—what would happen? The molecular dust resulting from the disintegration of the earth and the bodies upon its surface would be driven out into space under the driving of centrifugal force and would soon be scattered throughout space as individual molecules.

It is a good thing that there are laws that govern this earth else even research would not avail.

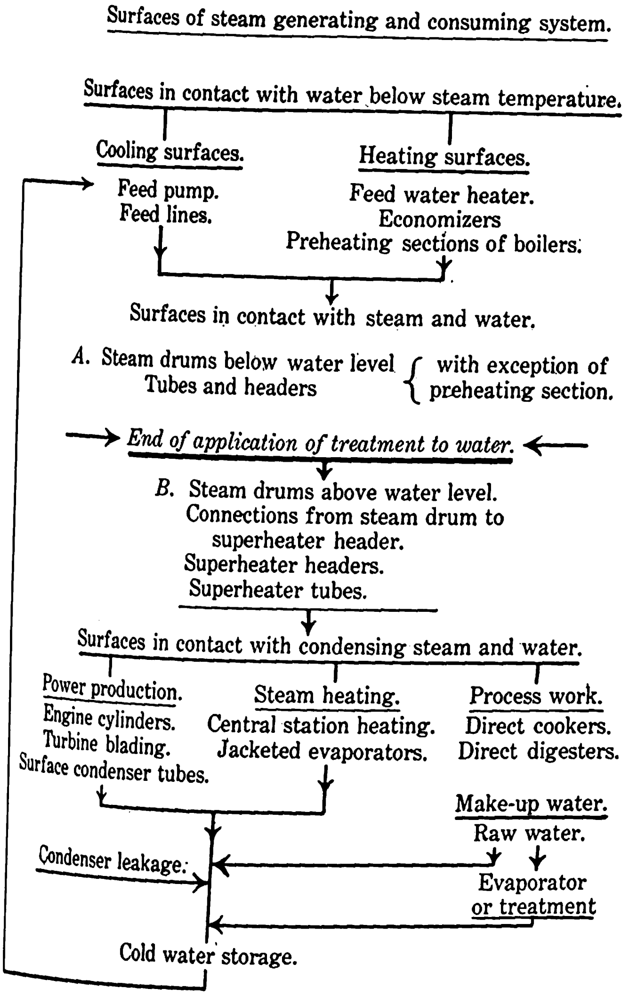
Boiler Water Conditioning With Special Reference to High Operating Pressure and Corrosion*

By DR. R. E. HALL

Physical Chemist, Bureau of Mines, Department of Commerce

The Scope of Boiler Water Conditioning

When the criterion for control of scale prevention on the evaporating surfaces is made the condition in the concentrated boiler water, then this control becomes an exact operation susceptible of an accuracy commensurate with all other operations in the boiler room. The responsibility in boiler water conditioning, however, includes more than clean surfaces. Corrosion in feed lines, economizers and the boiler is a function of the condition of the water, and must be controlled. Steam line and turbine blading deposits must be obviated by the system of conditioning. By the chemical treatment employed, the amount and character of non-condensable gases in the steam must be controlled in accordance with the intended use of the steam. All in all, the responsibility in boiler water conditioning ends not with the entrance of the water into the boiler but with the passage from the boiler nozzle of steam, the dryness and purity of which are defined by the uses to be made thereof.


Surfaces of steam generating and consuming system.
Surfaces in contact with water below steam temperature.
Cooling surfaces.
Feed pump.
Feed lines.
Heating surfaces.
Feed water heater.
Economizers
Preheating sections of boilers.
Surfaces in contact with steam and water.
A. Steam drums below water level
Tubes and headers
with exception of preheating section.
End of application of treatment to water.
B. Steam drums above water level.
Connections from steam drum to superheater header.
Superheater headers.
Superheater tubes.
Surfaces in contact with condensing steam and water.
Power production.
Engine cylinders.
Turbine blading.
Surface condenser tubes.
Steam heating.
Central station heating.
Jacketed evaporators.
Process work.
Direct cookers.
Direct digesters.
Make-up water.
Raw water.
Evaporator or treatment
Condenser leakage.
Cold water storage.

A clearer conception of the scope of boiler water conditioning can be obtained by reference to the above diagram of the surfaces at which it functions. Consideration of this diagram leads to the following outline for the problems of boiler water conditioning:

(a) Prevention of scale formation on surfaces
  (1) In contact with water but at which no evaporation occurs.
  (2) At which evaporation is occurring.
(b) Prevention of corrosion on surfaces (1) and (2) of (a).
(c) Selection of chemical treatment on the basis of non-condensable gases that are permissible in the steam.
(d) The control of sludges and soluble salts in the boiler water.
(e) The removal of entrained moisture from the steam.

Prevention of Scale Formation on Evaporating Surfaces

The following expression serves as a general criterion for the elimination of scale formation on the evaporating surfaces:

$$\text{Concentration in the boiler water of chemical used in treatment} = \text{Function of (a) the operating pressure, (b) concentration of sulphate } (SO_4) \text{ in the boiler water.}$$

This expression makes no limitations regarding the type of feed water to be used or as to the methods of conditioning which will be employed. It makes no specifications whatever regarding the methods which will be used for removing any sludges produced. It is a generalized statement of the fact that the two major factors to be considered in prevention of scale formation on the evaporating surfaces are operating pressure and the sulphate concentration in the boiler water. Two principles governing adherent scale formation on the evaporating surfaces must be recognized in order to define the term, "chemical used in treatment."

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*Abstract of paper presented at Midwest Power Conference, Chicago, Illinois, January 27, 1926. See also December 1925 issue of Proceedings of the Engineers' Society of Western Pennsylvania.

1. The adherent scales which grow in thickness are formed by deposition from the boiler water directly on the surfaces where found when the boiler is opened. This may be called deposition *in situ*. There are three substances which deposit from the boiler water in this manner, namely, calcium sulphate, and calcium and magnesium silicates.

2. The solubility of substances which form adherent scales decrease with temperature increase; vice versa, those substances which separate from the boiler water as sludge increase in solubility with temperature increase.

Therefore, the chemical used in the final conditioning of the boiler water must be one that, if maintained at the concentration defined by the operating pressure and the amount of sulphate present in the boiler water, prevents the formation of any calcium sulphate or calcium and magnesium silicates at the evaporating surfaces, and insures the separation of sludge-forming substances only.

This discussion has to do only with the final conditioning of the boiler water, and consideration will be given to but two substances which meet the requirements noted above, namely, sodium carbonate (Na_2CO_3, soda ash) and sodium phosphate (Na_3PO_4). Sodium carbonate and phosphate have been specified because they can be purchased in the market more cheaply than other carbonates or phosphates. It must be recognized, however, that they are used because of their available carbonate (CO_3) and phosphate (PO_4) content, and that other than their sodium compounds, as for example their potassium compounds, might be used if they were cheaper or if a special reason existed for their use,—as, for instance, the use of barium carbonate ($BaCO_3$).

Regardless of any pretreatment which may have been given to the feed water, the essential relation to maintain in the boiler water is expressed thus when soda ash is used for the purpose.

$$CO_3 = K_1 \text{ (at operating pressure } p) \times SO_4.$$

If sodium phosphate is used, then the expression becomes

$$PO_4 = K_2 \text{ (at operating pressure } p) \times SO_4^{\frac{3}{2}} \times D^{\frac{1}{2}}(SO_4)$$

In these expressions, CO_3, PO_4 and SO_4 are preferably measured in parts per million though grains per gallon may be used as well. K_1 and K_2 are specific for CO_3 and PO_4 respectively, and are constants for a definite operating pressure p, but vary with variations of the operating pressure. D refers to the relation of ionic to total SO_4 in the boiler water and is a function of the operating pressure and of concentration of SO_4. As an example of the application of these criteria at the operating pressure of 150 lbs. gage

$$K_1 = 8.83 \times 10^{-2}$$

Thus if the sulphate concentration in the boiler water is 1000 p.p.m., the concentration of CO_3 therein must be slightly more than 88 p.p.m., etc.

For the use of phosphate at this operating pressure

$$K_2 = 1.64 \times 10^{-4}$$

when concentrations are expressed as parts per million.

For a concentration of 1000 p.p.m. of SO_4, $D = 0.65$; for 2000 p.p.m. of SO_4, $D = 0.59$. Substituting these values in the general equation for the use of phosphate, we find that for a concentration of 1000 p.p.m. of SO_4 in the boiler water, the essential concentration of PO_4 necessary to prevent adherent scale formation is slightly more than 4 p.p.m. and for 2000 p.p.m. of SO_4 slightly more than 11 p.p.m. Simple types of apparatus are described for the determination of SO_4, PO_4 and CO_3 in the boiler room.

The Relation Between Chemical Used in Treatment and Operating Pressure

It is evident from the expression

$$CO_3 = K_1 \text{ (at operating pressure } p) \times SO_4$$

that the maintenance of scale free conditions depends upon keeping a definite supply of CO_3 in the boiler water. At boiler temperatures, however, soda ash decomposes according to the reaction

$$Na_2CO_3 + H_2O = 2\ NaOH + CO_2$$

and the rate of its decomposition is a function of the operating pressure, and the rating at which the boiler is operated. These two, therefore, in conjunction with the concentration of SO_4 in the raw make-up water, and blowdown practice are the elements which control the feasibility or infeasibility of maintaining the necessary CO_3 concentration. Thus higher operating pressures are characterized by more rapid decomposition of CO_3; and at the same time by the necessity for maintaining higher CO_3 concentration, since the value of K_1 is greater at higher than at lower operating pressures. In a boiler operating at low rating, it may be possible to maintain the necessary amount of CO_3 in the boiler water while in the same boiler at high rating, the more rapid decomposition of CO_3 may render such maintenance impracticable unless blowdown of uneconomical proportions is resorted to. The basic cause for these troublesome limitations in the use of soda ash lies wholly in its decomposition into caustic soda and carbon dioxide. Also apart from the uncertainty of maintaining satisfactory CO_3 concentrations, the high caustic alkalinity developed in this decomposition makes it impossible at higher operating pressures to keep within the alkalinity-sulphate ratio recommended in the proposed boiler code as insurance against embrittlement. The remedy lies in the substitution for CO_3 of a substance satisfactory from the standpoint of scale prevention and entirely stable at the operating pressures. It has been one of the most pleasing developments of this investigation to establish the proof that PO_4 gives beautiful results on the side of scale prevention and that the total alkalinity necessary in the boiler water can easily be kept well within the limits recommended from the standpoint of caustic embrittlment.

A satisfactory and economical answer to the complete conditioning of water for high pressure operation may be given as follows:

If the make-up water is evaporated and the only impure water entering the boiler consists of the condenser leakage, then the conditioning of the boiler water with phosphate is the only chemical control necessary. If the make-up water is not evaporated and is of some magnitude, then economy demands the pretreatment—with lime and soda ash for any water or by a base exchange process if the water is not high in temporary hardness—followed by the final conditioning of the boiler water with phosphate. In the pretreatment, however, any addition whatever of excess chemical must be avoided else detrimental concentrations of caustic alkalinity will develop in the boiler water. If it is deemed desirable to limit the amount of soluble solids in the boiler water and the feed water is one that contains sulphate, a variation in pretreatment may be made by using barium carbonate in place of sodium carbonate, thus removing much of the sulphate as well as the calcium. In any event, however, the final control of the boiler water must be based on the use of a suitable substance such as phosphate.

Prevention of Scale Formation on Feed water Lines and Preheating Sections

The problem of scale prevention is much simpler on these surfaces than on the evaporating surfaces since (1) there is only one main constituent in these scales, namely, calcium carbonate ($CaCO_3$), (2) deposition of insoluble solid material occurs by reason of supersaturation throughout the body of the water and not at the surfaces alone as in the case where evaporation is occurring, and (3) no decomposition of the chemical used in treatment occurs.

In order to prevent scale formation on these surfaces, it is necessary that no bicarbonate (HCO_3) remains in the water, and it is advisable that a small concentration of caustic soda ($NaOH$) and loose crystals of suspended calcium carbonate be present. This condition may be maintained in a water which has been correctly treated externally or by using the excess caustic alkalinity in the boiler water itself. The latter control involves recirculating water from the boiler through the feed lines or the preheating sections.

The Prevention of Corrosion on the Surfaces in Contact With the Feed or Boiler Water

On the basis of experiments which are described under this heading, it is concluded that in general any corrosion of the boiler system surfaces in contact with water is electrochemical in character. Anodic conditions in the metal develop from differential oxygen concentration, especially in feed lines and economizer tubes, from impurities in contact with the metal (as mill scale) or from a state of strain or local differences of temperature. The control of corrosion, therefore, signifies so conditioning the water that at any anodes which may develop, passage of current generated results not in the dissolution of the boiler metal but in the discharge at the anode of some component in the boiler water. It is our belief based on experimental work and operating control now in progress (1) that hydroxide (OH) is specific in this respect as regards sulphate waters, and satisfactorily inhibitive for practical purposes as regards chloride, (2) that the control for inhibition of corrosion is as exact as that given for elimination of scale formation, and (3) that even in the extreme case of a raw water saturated with air, feed line or economizer corrosion can be reduced to negligible proportions.

Control of Non-Condensable Cases in the Steam by Conditioning of the Boiler Water

In general, the necessity for controlling the concentration of carbon dioxide in the steam arises most frequently. For such control, the obvious thing to do is to keep all carbonates so far as possible from the boiler water. If the make-up water is evaporated directly, control of the boiler water with PO_4 limits the quantity of carbon dioxide to the amount derived from condenser leakage. If the feed water is given primary treatment with lime and soda ash, it is necessary to avoid excess of treatment and to use a secondary control with PO_4 on the boiler water. If the feed water contains temporary hardness and is treated by a base exchange process, it may be necessary to remove the excess sodium bicarbonate in the water after treatment by the use of acids or other means, and the final control must be established on the boiler water with a chemical which does not decompose at the operating pressure in question.

Other Factors in Boiler Water Conditioning

The control of sludges and soluble salts in the boiler water, their relation to wet steam and the removal of any boiler water and its suspended insoluble material from the steam before it leaves the boiler nozzle are as integral parts of any complete system of boiler water conditioning as the factors which have been considered already. It was the purpose of this paper, however, to present those features of such a system in which the Bureau of Mines is actively cooperating.

This has been done, and I must, therefore, extend this discussion no further.

Acknowledgements

In this research covering a period of four years, it is impossible adequately to recognize the achievements of all those associated in the development, but the author takes pleasure in ascribing any success attained to the unstinted support which has been given by Mr. A. C. Fieldner, Chief Chemist of the Bureau of Mines, and Mr. J. M. Hopwood, President of the Hagan Corporation, and their respective organizations.

Patent and Trade Mark Relief*

There was held at the Hague from Oct. 8 to Nov. 6, 1925, a conference to consider the revision of the Convention of the Union for the Protection of Industrial Property. The principal changes made relate to the working of patents, the granting of a period of grace for the payment of taxes, the prevention of the piracy of trade-marks, and the repression of unfair competition.

The original Article 5 relating to the working of a patent has been cancelled and a new one inserted wherein the granting of compulsory licenses is substituted for forfeiture as the penalty for non-working, the declaring of a forfeiture being prohibited, except in a case where the granting of compulsory licenses was found to be not sufficient to prevent abuses of the monopoly rights granted by the patent. This article further provides that the period of three years, which must be allowed before any penalty can be imposed for non-working, is to be reckoned no longer from the filing of the application, but from the date of the actual grant of the patent. Thus the risk of forfeiture for non-working is practically eliminated.

A new Article 5b is included, which provides that a period of grace of at least three months must be granted for the payment of any taxes with reference to industrial property rights beyond the time fixed by law and that, with respect to patents of invention, such period must be at least six months, or a provision made for restoring patents which have become forfeited for non-payment of taxes. Forfeiture for non-payment of taxes through accidental causes is thus practically eliminated.

As to trade-marks, each country agreed to provide for the cancellation of a trade-mark registration well known in that country as being the trade-mark of the citizens of one of the other countries of the Union, and that the expiration of a registration in the home country would not shorten the term for which registration of the mark had been granted in any of the other countries of the Union, and that therefore the renewal of the registration in the home country would not necessitate the renewal of the registrations in the other countries prior to the expiration of the term for which the registration was granted. The requirement that articles sold under a trade-mark bear an indication of its registration was also dispensed with. This provision therefore furnishes an effective remedy against the piracy of well-known trade-marks.

As to unfair competition, in addition to the agreement of the old convention that each country would grant to the citizens of the other countries an effective remedy against unfair competition, it was agreed that any act contrary to honest usages in commercial matters would be regarded as an act of unfair competition, and especially any acts whatever which would be likely to create confusion with the products of a competitor and false allegations of a nature to discredit the products of a competitor. This amendment will be of very material advantage especially in those countries which have not developed, as in the United States and Great Britain, a well-defined system of jurisprudence with respect to unfair competition.

While the conference did not go as far in the matter of working patents and the taxes thereon as the United States delegates desired and proposed, very material relief has been afforded from the former onerous conditions.

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*Synopsis by H. L. Godfrey of the Report of Thomas E. Robertson, Commissioner of Patents, at the Hague Conference.

Surface Air Coolers with Hydro-Electric Generators

The first use of fin type surface air coolers with hydroelectric generators will be made in connection with the new station which is being built by the Louisville Hydroelectric Company just above Louisville, Ky., on the Ohio River. Because of the use of soft coal in the city and the consequent trouble which would be caused if open ventilation of equipment was used, it has been decided that the closed system of ventilation would be preferable. The major use of surface air coolers has been with turbine-generator equipments.

The generating equipment of the new station will include eight 10,000-kv-a., 14,000-v., 100-r. p. m. hydroelectric generators, each equipped with fin type surface air coolers.

The development is being made at the site of one of the state-built navigation dams. According to the season, the head varies to a maximum of 40 feet. The power developed there will be used in and around Louisville.

Philadelphia—a Future Iron and Steel Center[*]

By WALTER WOOD

President, R. D. Wood Company

THE subject as given for the address today appeals to me as belonging to a period about sixty or seventy-five years ago, when the Schuylkill Valley and the Lehigh Valley were large centers of production, with little furnaces scattered all up and down the valleys and we were shipping cast iron pipe to Birmingham.

I speak of those shipments simply to show the predominance of this region before the Pittsburgh and Alabama regions developed. What I am going to say will be from impressions and memory; I will try to be as accurate as I can in the figures I give, though they will necessarily have to be largely general and approximate, yet I think you will get the picture of the present situation.

The fundamental requirement of a harbor today is water; and we have practically thirty-five feet depth of water. That is sufficient to bring to this port tramp steamers of almost any size. A 20,000 ton steamer would just scrape through the 35-foot channel; but that is an unusually large size. Most tramp steamers carry from five to twelve thousand tons, and a channel thirty feet deep will take them. We have cheap transportation, one of the fundamentals for an iron center.

Any of us can build a blast furnace in his back yard,—if he has a bank account which will permit doing so; but it would be useless unless he has the ore. For our little furnaces fifty years ago our local supplies were ample. At present, with the large demands of modern furnaces, there are but a limited number of ore supplies in this immediate neighborhood which are sufficient.

The Atlantic Ocean is the largest ore mine in the world, and an ore mine which gives us almost any quality of ore we may want,—whether from Newfoundland, Sweden, Turkey, Greece, North Africa, Brazil or India. We have access to all those ores, at rates which compare very favorably, although those places are so far away, with the rates the furnaces have to pay for local ores. As an illustration: to bring Lake Superior ores from the Mesaba Range to Philadelphia costs about three and a half dollars a ton. I doubt if there is any ore imported—or more than very few ores carried on the Ocean—at a higher rate than that.

We have, therefore, in Philadelphia access to the largest ore fields there are,—and all qualities of ore. But there is no use in building blast furnaces in Philadelphia unless we have a market for the product. Lacking that it is useless. The Philadelphia Foundrymen's Association, in the past month or two, took a poll of the consumption of foundry iron in Philadelphia and those parts of the states of New Jersey, Pennsylvania, Maryland and Delaware, within a reasonable distance. They sent out 453 inquiries. They were fortunate in receiving answers to as many as 240, because a great many things go into the waste paper basket.

The tonnage reported in the 240 replies was 652,454 tons. Of the 213 which made no report we can safely assume an additional 50%, thus making total requirements of over 900,000 tons of foundry iron within measurable distance of Philadelphia.

The amount of pig iron used in the foundries of the United States is small compared with the amount used in the steel plants; roughly about 1 to 9. The total amount of steel ingots made in this immediate neighborhood is approximately two million tons; and if you say half of that is made from scrap, the million tons requires pig iron.

Therefore, within a certain radius of Philadelphia there is a consumption of approximately two million tons of pig iron, which must be supplied by our friends at Conshohocken, Birdsboro, Bethlehem, Robesonia—I must not forget Robesonia, because it is unique in its ability to obtain cheap ore. One hundred years ago, four thousand dollars were paid for the right to take all the ore they needed for their furnace, *in perpetuity*. And the size of their furnace has grown from one diameter to another and still another; from one having probably an eight-foot bosh they now have twenty or twenty-two-foot bosh,—and still the contract holds. The wording is,—"Ore sufficient for one furnace as long as water flows and grass grows,"—and all for a trifle over four thousand dollars. And the mine is not yet exhausted.

Having a market at our hands, and having ability to get ore more cheaply by water than by rail, let us see what that means to our city. It means this: a bank of furnaces on the Delaware to supply that two million tons would be folly, because there are others already here making pig iron, and we must go fifty-fifty with them, or at some proper proportion; but if we put up a bank of four furnaces of the ordinary size they would bring about twenty to twenty-five thousand tons of cargo into this port weekly, and during a year, and every year. With empty vessels lying ready to take our exports it would be over a million tons a year of each importation and exportation,—

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[*] Address before the Engineers Club, Philadelphia, Pa., Dec. 15, 1925.

together with the advantages that come from converting ore into pig metal.

Another fundamental in making pig iron, as we all know, is fuel. For the past thirty years, or more, local furnaces have been using coke,—making it in bee-hive ovens, and bringing it all the way from west of Altoona. But now every furnace man feels that in order to get his coke economically he must make it in by-product ovens.

I doubt if there is any larger furnace company but has, or wishes it had, by-product ovens to supply its coke,—because such an oven has also its residuals and has its gas. If the gas can be sold, the company is lucky. Schwab sells his to Baltimore. I think Bethlehem sells its gas to Harrisburg. The furnace at Boston, which has by-product ovens, supplies gas to users in that neighborhood. Recently a furnace has been built at Troy, with a by-product oven, which sells its gas to Albany, Troy, Schenectady and the immediate neighborhood.

In that way you have other sources of revenue in the manufacture of pig iron, which at the moment seem to fit in every desirability with our Philadelphia situation. We all want cheap gas in Philadelphia, and gas made by a by-product oven would be the cheapest the U. G. I. could make—at least, for a very large portion of what they deliver.

The by-product plant which was put up in Jersey twenty years ago was put up when it was very desirable to have by-product ovens. The high prices of residuals made the gas available at a very low cost. Prices have changed since, so that by-product gas is not quite velvet; but it approaches that status more nearly than gas made in any other way.

If we have four furnaces,—one making foundry iron, perhaps; one making another kind; and another another kind, to provide for the varied demands from the different kinds of manufacturers, we should have enough gas, and that of the cheapest character, to supply the requirements of the City of Philadelphia.

I have tried to touch the high spots, and now let expert engineers put all the figures together accurately, to determine how far Philadelphia can in the near future, or at any time in the future, become again a blast furnace center.

We have the ore. We have the market. We have the use for the gas from the by-product oven. And we have the coke. A large by-product coke plant would have been a God-send in the past two months. If we could have felt that there were five or ten thousand tons of coke being made next door to us, some of us would have been very much more comfortable than we are now.

There is one other thing I would like to mention, and that is, that the gas business is on the point of large development. Ten years ago 600 B.t.u. was the requirement; now it is 530, and we are looking forward to making 450 B.t.u. gas; and when it gets to that, and all the small points, and expensive points are eliminated, not only will we be using gas for illumination and cooking, but we will be using it for heating the furnaces which warm our houses.

We are within fifteen or twenty per cent of that situation, and while it is not in sight now, any man who is accustomed to the gas business knows it is a thing to look forward to, and to look forward to with pleasure—turn on your gas in October, regulate the heat of your home with a thermostat, and turn it off in May,—have no dirt or dust or ashes in your cellar, and no man shoveling coal.

Reduction in Varieties of Chasers for Self-Opening Die Heads

Recommendations which will mean a reduction of 75 per cent in the sizes and varieties for chasers for self-opening die heads, used in automatic screw cutting machinery, were adopted by a general conference of manufacturers, distributors and users held under the auspices of the Division of Simplified Practice on December 4, 1925.

This product, the manufactured value of which amounts to some $5,000,000 annually, is used in a wide range of mechanical goods, from sewing machines to locomotives, from typewriters to power plants, automobiles, electrical fittings, and other articles affecting every-day life. And the program adopted by the conference is estimated to hold a potential saving of $500,000 a year in manufacture and distribution, and a large indirect saving to every user of machine screws, through interchangeability of parts.

Edison Medal Awarded to Professor Harris J. Ryan

The Edison Medal for the year 1925 has been awarded by the Committee of the American Institute of Electrical Engineers to Harris J. Ryan, of Stanford University, California, "for his contributions to the science and the art of high-tension transmission power."

During Professor Ryan's twenty years at Stanford, he has been a pioneering leader in high-voltage transmission, upon the development of which largely depends the future growth of the Pacific Coast region. About three years ago the first 220,000-volt power lines were successfully put into commission by California companies, and Professor Ryan co-operated with the engineers in finding ways to cope with the insulator problems encountered, and it is on the solution of similar problems that his genius in the research field is expected to continue an outstanding advantage to science.

Why American Engineering Council?*

By PRESIDENT DEXTER S. KIMBALL

CIVILIZATION at best is a complicated matter. In all times and at all places wherever men have congregated with any extended use of division of labor, the problem of insuring justice and a square deal for all has proven to be a difficult and baffling task. Of the many basic conceptions for accomplishing this result I shall speak of only two.

The first method and one which was quite common among our remote ancestors was to settle these matters by edict, some ruler in whom wisdom was supposed to reside acting as judge and arbiter. Such methods are well illustrated in the laws of Hammurabi which were promulgated over 4000 years ago, the code being one of the earliest recorded documents of this kind. These laws are dogmatic in character and are based upon the general principle of "eye for eye and tooth for tooth." In a simple handicraft civilization, and under a wise ruler, such methods possibly may suffice, though the ultimate success of the effort to limit natural economic laws by edict, as is done in the Code of Hammurabi, may be seriously questioned.

The second method of settling the difficulties of civilization to which I shall refer is by an appeal to experience and precedent as is done so largely in our present legal system. So far as the civilization to which we are the heirs is concerned this method found its first great expression in the Justinian Code promulgated in the Sixth Century and partly because of which we still live beneath the shadow of the Roman eagle. The logic of this method is sound since it is reasonable to assume that similar conditions necessitate similar treatment and if a certain procedure is found to be sound and successful in one case it is reasonable to assume that it is applicable to other cases where the conditions are the same. In a civilization where the basic conditions of living have become stabilized, as occurred in China, an appeal to precedent representing a vast body of accumulated experience might be amply sufficient. And even in a civilization where the conditions of existence change at moderate speed it might be possible for law makers to keep reasonably abreast of progress and settle the affairs of the nation with considerable fairness.

During the last seventy-five years the basis of civilization in this country and a few others has been changed in a greater degree than in all the preceding centuries of man's existence on this planet. Furthermore, the rate at which this change has been brought about vastly exceeds anything of which we have record and there is no sign, as yet, that these rapid changes will not continue for some time to come. These basic industrial changes have brought about marked changes in our social and political fabric and have created conditions with which we have had little or no previous experience. The problems incident to these new conditions often cannot be solved by an appeal to precedent, much less to edict. As a consequence we often flounder about hopelessly in our law-making efforts simply because we do not understand the complex causes of these results.

Now these basic changes have been brought about largely through the work of the scientist and the engineer and the latter is peculiarly well informed as to many of the basic causes that have produced such troublesome results. The engineer has performed his truly marvelous work by using the old though still little known methods that we speak of as scientific that he has acquired from the mathematician, the chemist and the physicist, and he believes, with very good reason, that the same logical methods that have built up modern civilization will be equally efficacious in curing its ills and perpetuating it. And it should be noted that in the application of the scientific method edict has no place and precedent may be trusted only when it has been proven to be sound under the most exhaustive tests. This is not peculiar to engineering as a brief consideration of the field of medicine will reveal. And those who have built up modern medicine using the same scientific methods of attack have made a contribution to modern civilization second to no other group of scientific workers.

When, however, the scientist or the engineer is brought into contact with law-makers and others who are trying to adjust the social and political machinery of our country and particularly when he is called upon to co-operate with such others it is often to him a distressing experience to find them wholly ignorant of logical scientific methods of attacking problems, but instead finds them searching for precedents where none exist, worse still using precedent that does not apply or possibly trying to settle the matter by compromise on the ground of expediency alone.

The American Engineering Council is, therefore, an effort to place the knowledge and experience of the engineer at the service of the city, the state, and the nation for the solution of such social and political problems as may properly fall within his knowledge and experience. And in so doing we have no illusions as to the limitations of this knowledge and experience. We are only too well aware that the solution of these problems will require the best efforts of many men of many minds. But we do affirm that if the engineers of this country will attack many of these national problems, especially those that have their origin in the complexity of industry, with the same energy and the same methods that have been used so successfully to create modern industry they can make a great contribution to this commonwealth. They can do much to make this world a happier one, for it will be a more intelligent world where many of these difficult industrial, social and political problems, that we are now trying to solve by edict or inapplicable precedent, will have been brought into scientific analysis.

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*Remarks at Dinner of American Engineering Council, Chevy Chase, Md., January 15, 1926.

Development in Industrial Standardization During 1925

By C. E. SKINNER,

Chairman, American Engineering Standards Committee

NINETEEN HUNDRED TWENTY-FIVE has shown important developments in the growth of the industrial standardization movement. One of the most important of these has been the increase of active interest on the part of industrial executives. A conference of first-line executives, held early in the year, organized a committee from their number to serve as an advisory committee to A. E. S. C., and these men are now giving time and assistance to the solving of national standardization problems. Formerly, the matter of standardization had been left largely to technical man, but it is now generally recognized that standardization is a managerial problem of the first rank.

Of special interest to the factory owner and manager is the Directory of Specifications, published in August, 1925, by the Department of Commerce. This compilation lists approximately 27,000 existing specifications covering 6,000 commodities, and it will be found very useful in connection with purchases. The astonishing multiplicity of specifications on the same subject has brought sharply forward the problem of unifying them into consistent groups. Such unification is an industrial and economic problem of the first importance.

In so brief a review the standardization activities of the hundreds of organizations, trade, technical and governmental, cannot be listed. However, the work of the A. E. S. C. is typical of the standardization movement as a whole, since the Committee acts as a general clearing house, and each project promulgated under its auspices represents the combined effort of many such organizations.

In the field of mechanical engineering, a system of limit gaging, together with a comprehensive scheme of fits, which is probably the most important project ever carried through by the A. E. S. C., lays the basis for the carrying out of complete interchangeable manufacture on a national scale, as well as for facilitating mass production within the individual factory. When this work permeates the structure of American manufacturing industry, the resulting savings will run into enormous figures. Two important dimensional standards, dealing with cold-finished shafting, and square and flat shafting keys, have also been approved.

At a conference in December a comprehensive program for the standardization of drafting room practice was launched. There has been great interest in this subject and it bids fair to become a matter of first importance on account of the wide range of industries which it affects. Although many individual factories have already worked on the standardization of drafting room practice, we are on the whole far behind European countries in bringing about the economies which are possible through national standards.

In the electrical field, the 1925 edition of the National Electrical Code, the bible of the electrical wiring industry, has been approved. Also a system of connections and markings for electric power apparatus, representing the combined effort of a large number of engineers, has been approved as American Standard, after standing the test of several years practical application on a large scale. A standard for instrument transformers has been recommended for approval and a standard for synchronous converters has also been submitted. For the first time complete national agreement has been reached on a Safety Code for Aeronautics, in the development of which the military and civil branches of the Federal Government and the commercial and public agencies interested in the subject were represented. The code deals with standards of safety for design, construction, testing and operation of aircraft. Good progress has been made in the code for automobile brakes and brake testing.

The mining industry is the most recent of the great industries to take up standardization on a comprehensive scale. The leaders in the movement have been the U. S. Bureau of Mines and the American Mining Congress. In addition to the 16 standardization projects now under way, under the procedure of the A. E. S. C., three more have been officially proposed. A notable step in the prevention of mine explosions has been the completion of a code for rock dusting of coal mines, through the co-operative effort of all interested groups. Catastrophes due to coal mine explosions can be prevented by the simple expedient of spreading rock-dust thickly enough to cause an incipient coal-dust explosion to die out rather than to travel through the mine atmosphere.

In the field of industrial safety, satisfactory progress has been made on a program of some 40 codes, most of which are applicable to factories. Seventeen of these have been completed, and work on half of the remainder is well advanced. Codes for paper and pulp mills, and elevators and escalators, were completed and approved during the year.

The fourth year of the work of Mr. Hoover's Division of Simplified Practice has shown even more rapid development than heretofore. In all, 39 simplifications have already been carried through, 10 others are in the final stages, and 65 additional surveys are now under way. Over two hundred industrial groups are cooperating in the various projects.

Approximately 350 specifications have been promulgated by the Federal Specifications Board, which means that these specifications have been unified as between the various branches of the Government. A leading part in this work is being taken by the Bureau of Standards, the Director of the Bureau being ex-officio chairman of the board.

Standardization on an international scale is still in its infancy; yet through the cooperation of the various national standardizing bodies there has been real accomplishment in several subjects. Of special interest, on account of its relation to the use of specifications in the development of foreign trade, is the First Pan American Conference on the Uniformity of Specifications, which was held in the first part of January, 1925, in Lima, Peru. It was decided to hold another such conference in the United States within a year or two. In connection with the meeting of the International Electrotechnical Commission which is to be held in New York in April, 1926, there will also be held in New York a conference of the chairmen and secretaries of the national standardization bodies, for which the American Engineering Standards Committee will act as host.

With some important exceptions, manufacturers generally have carried on their standardization work as a more or less incidental part of their engineering and production activities. But thorough-going standardization simplifies and clarifies every step in the work of the manufacturer from the solicitation of the order to the mailing of the receipted bill. Definite organization for standardization work within companies has thus become a pressing managerial problem.

Another special problem on which marked progress should be made during the coming year is to get organizations of distributors to play their proper role in the standardization movement. It is generally recognized that the most important industrial and economic wastes are in the field of distribution, and that broad programs of standardization are essential to the elimination of this waste. Mr. Hoover, for example, rates standardization as second only to statistics in its importance in the whole distribution problem.

Civil Aviation Findings of Joint Committee Lead To Classified Recommendations

A SURVEY of the economic aspects of aviation throughout the world became available to the public with the release of the detailed report on this subject by the Department of Commerce and American Engineering Council. The survey has been in progress since June, 1925, by a joint committee.

The promotion of civil aviation in the United States is predicated, in the committee's opinion, upon three underlying principles:

"First, the development of commercial uses of aircraft is of great importance industrially and to the national defense.

"Second, air navigation should and can be developed primarily as a constructive agent for the public welfare.

"Third, the provision of essential air navigation facilities is a public responsibility. If these facilities are provided, direct subsidies to civil aviation enterprises are unwise and unnecessary.

"The committee finds that certain fundamental difficulties are retarding the development of civil aviation in the United States, which may broadly be summarized as:

"1. The need of a definite legal status and Government control.

"2. The need of an established Government policy to encourage the civil and industrial uses of aircraft.

"3. The need of commercial aircraft and equipment best adapted to profitable commercial operation.

"4. The consequent lack of public and business confidence and support."

The committee has made the following recommendations to remove these fundamental handicaps:

1. That Congress enact a civil aeronautics law providing for the establishment of a Bureau of Civil Aeronautics, recognition of the public right of free air navigation, to define the liability of interstate commerce air carriers, to reconcile the rules of water navigation with air navigation, and to correlate the laws relating to aviation.

2. That the several states enact statutes authorizing the municipalities to acquire and maintain with public funds and to lease landing fields, and that for the present the other phases of state jurisdiction relative to aeronautics be permitted to develop under the common law.

3. That the President submit to the Senate, and the Senate ratify with suitable reservations, the International Air Navigation Convention, which has been signed by representatives of the United States and has been ratified by most of the important countries except the United States.

The committee further recommends that the Government develop such policies regarding civil and industrial use of aircraft as the following:

1. That the Government do not engage in non-military flying activities which can be properly performed by private operation.

2. That the use of commercial aircraft in non-military Government activities be extended where aircraft may be usefully employed. Air mail, forest patrol, agricultural, entomological and Coast Guard services, aerial photography, map making, etc., should be conducted by private agencies under contract wherever possible.

3. That, under the legislation recommended, the Federal Government without delay provide air transportation with essential facilities, such as lighted airways, emergency fields, maps, charts, radio, and adequate weather service.

4. That Congress authorize the War and Navy and other Departments to permit a reasonable use of Government landing fields and ground facilities for commercial aircraft operations, where commercial facilities are not available.

5. That the Post Office Department actively encourage the establishment and extension of air-mail services, and that, as rapidly as it is possible to contract with responsible private operators, the Post Office Department retire from the ownership and operation of such airmail routes, and that it turn over to the proposed Bureau of Civil Aeronautics its airway equipment.

6. That, under the direction of the President, the executive heads of the departments concerned shall provide for the interdepartmental co-ordination of all non-military Government air activities in order best to promote civil aviation.

In the field of commercial aviation and equipment the following recommendations are made:

1. That Congress appropriate for, and authorize the proper non-military agencies of the Government to purchase special types of civil aircraft and equipment, designed and constructed by private industry under the joint direction of the executive heads of all the departments concerned.

2. That present restrictions affecting purchases by governmental agencies be modified to permit the executive heads of the departments concerned to purchase aircraft, aircraft engines, accessories and parts in such a way as best to promote the Government's interest and to give equitable compensation to the manufacturer for design development pertaining to the materials so purchased.

3. That Government purchases of air-craft be arranged to conform to a definite and continuous program, which will give the greatest aid to the aircraft industry.

4. That the Government carry on fundamental aeronautical research in the interest of civil aviation.

5. That the Government do not compete in the design, construction, and major repair of civil aircraft, nor handicap civil aviation by indiscriminate dumping of obsolete aeronautical material.

6. That the Government encourage the exportation of commercial aircraft, thereby extending to the manufacturers a benefit which will of necessity result advantageously to the Government as the principal purchaser of the aircraft industry.

In order to secure public and business support for the proper development of aviation, the following recommendations are made:

1. That underwriters base insurance rates to responsible aircraft operators on their record of performance, rather than upon average figures which include military hazards and the performance of irresponsible itinerant flyers.

2. That life and accident insurance companies reconsider the risks incident to specific kinds of flying, and modify accordingly their restrictions on aeronautical activities of policyholders.

3. That investments in civil aviation enterprises should be made only with full knowledge of the integrity and competence of all those involved and after careful scrutiny of the proposed financing, routes, equipment, depreciation rates, operating personnel, and character, source, and probable volume of traffic.

The Varied Uses of Asphalt in State Highway Work*

By **B. E. GRAY,**

Division Engineer, West Virginia State Road Commission

WEST VIRGINIA is essentially a state of mineral production such as coal, oil and gas, although it has a large agricultural area, and with a blue grass acreage greater than Kentucky. In the west and northwest large manufacturing industries are building, so that conditions of traffic vary widely from one section to another. The state is very mountainous, being in the heart of the Alleghanies; the ranges run north and south, so that east and west routes cross the mountains at right angles, and other routes follow the valleys and parallel the water courses. The geology is old, with the strata dipping and twisting, so that slips are of common occurrence in certain sections and in many cases it is difficult to hold a road bed.

Road development is rather recent and in 1922 only about 1,000 miles of improved road had been built on the Class "A" routes of the State. This same year marked the active beginning of road building as a State proposition; the new State Road Commission (acting under constitutional amendment and a $50,000 bond issue) having been organized in 1921. The total road mileage in the State approximates 35,000 miles, and the designated State Route mileage about 3,500 miles, or 10%. Of these state routes, approximately 800 miles had been under county control, divided as follows: 37% graded earth, shale and gravel, 32% bituminous types, and the remainder rigid types. This mileage was taken over under state maintenance, and from its varying degree of non-maintenance has been brought up to a condition of useful service under present traffic conditions. By 1923, 1,100 miles of new construction was under way, made up as follows: 63% grading shale and gravel, 24% bituminous types and the balance rigid types.

In 1924, over 2,000 miles was under construction or maintenance, and in about the same ratio as stated above. At this time (1925) the total mileage under improvement approximates 2,500 miles and work is being completed at the rate of 2 miles each working day.

There is a wide variation in the quality of stone found in the different sections of the state; excellent limestone and sandstone being in abundance in the eastern sections, with softer sandstones in the central and southwestern portions. River gravel of good quality is obtained from the Potomac and Ohio rivers. Every effort is made to use local materials not only because of saving in cost but also because more rapid construction is possible.

Oil penetration macadam is widely used, with knapped and crushed stone base, and with a 3" broken stone top course. Base thickness varies from 5" to 10" according to sub-grade conditions, and is almost invariably made from local stone. Top course limestone is shipped in by rail or hauled by truck from local plants. Some work is being done with 2½" top with good results.

The reason for letting such a large mileage of grading work with temporary surfaces of shale and gravel is to permit a settlement of the rather heavy cuts and fills necessitated by mountain construction. Some idea of this may be gained when it is noted that excavation runs 12,000 to 15,000 cubic yards per mile in many instances. Such a procedure enables the department to maintain the newly graded road for one or two years before surfacing, and by the addition of shale, gravel or other similar material to thoroughly stabilize the subgrade. All bad drainage conditions are corrected during this period and when surfacing is later placed, greater durability and therefore lesser maintenance costs are the result. Too much emphasis cannot be placed on proper drainage, but this fact is so well known, that no further comment is necessary.

Another type of bituminous construction used, especially on graded roads of shale and gravel, is known as oil-finished macadam or "puddle macadam." In this type, the 3" top course is laid in the same manner as water bound macadam, up to the point of application of the water. Ordinary dust and screenings are used as binder, rolled in thoroughly dry, and the excess brushed off with hand brooms. To the surface thus prepared, cold oil or tar is applied at the rate of ¾ gallon per square yard, (with pouring pots), covered with ¾" chips and rolled. This top course work has been done largely under traffic, due to which hand pouring is required. It also makes it possible to bind up each day, all top course laid, preventing ravelling and other deformation of the surface due to traffic. When a long section of top course has been bound in this manner, a second application is applied at the rate of ½ gallon per square yard and additional chips apply as cover coat. More recently, a hot asphalt seal coat has been used, in place of the cold treatment originally specified, and with very good results. This type has given excellent service and permits the use of crusher run output on local quarry installations. Sandstone both for base and top gives equally good results as with limestone.

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*Paper read before the Fourth Asphalt Paving Conference, Detroit, Michigan.

Topeka and sheet asphalt tops have been constructed, using old macadam as a base, and with very satisfactory results. Such a road was built three years ago, using an old turnpike as a base, new stone being added to fill all depressions and to bring the road to proper grade and crown. This stone was thoroughly filled and rolled, and a 2" Topeka top laid 18′ wide and without any concrete curb or edging. It takes a very heavy north and south traffic, and has required practically no surface maintenance, the only repairs being a few yards area which failed because of bad drainage.

Some of our most interesting work has been in salvaging old macadam roads through surface treatment. Many of the old turnpikes had been built with intermittent additions of broken limestone, hand knapped, and consolidated under traffic, and had reached such a point of solidity that they only required capping to be made into useful surfaces. Holes were filled with clean stone filled and rolled, but no new stone added to the road as a whole. A cold surface treatment of ¼ gallon per square yard was then given, covered with chips and rolled. A few days later a second ¼ gallon application was applied chipped and rolled as before. In several cases where the surface was wavy, a road grader was run over the road after chips were applied, and before rolling. This cut down the high places, and carried the surplus coated chips ahead of the blade, thus filling the depressions. This practice corrected the rough condition to a large extent, and at a low cost. A large chip is used in all surface treatment work, ranging from ½" to 1½" in size. It is found that with this size, the tendency of the mat to shove and ridge under traffic is much reduced, that a non skid surface is formed, and that an appreciable addition in thickness of pavement is obtained. After the bituminous coat has been once formed with the lighter oils, future surface treatments consist of ¼ gallon applications of hot resurfacing asphalt using large chips. Great care is necessary not to obtain an excess of bitumen, as it is always easier to make a light additional treatment, than to correct a wavy surface. A mat built up in this manner will last for three or four years between treatments, and is therefore a most economical type, when low first cost is considered.

Pavements of narrow widths, such as 9, 10, 12 and 14 foot sections are being gradually widened and strengthened under maintenance, through additions of stone at the edges, and surface treatment. Within a year it is difficult to see where the addition was made.

Brief mention will be made of results obtained from the use of light asphaltic oils on shale roads. A very excellent quality shale is found in the northeastern section of the state, being really a natural sand-clay mixture of the most stable character.

These shale roads rarely break up in the winter and can be traveled at all seasons of the year comfortably, except during July and August, when they become very dusty. Last year several sections were treated with 50% cold asphaltic oils and with fair results. This year about 75 miles were treated with a ¼ gallon application and are largely satisfactory. In some sections where the shale was unusually high in silica, the results were surprising. A surface was obtained that closely resembled macadam pavement. The shale of itself is structurally strong enough to carry the traffic, and the asphalt makes a cover coat which prevents the abrasion of the surface. In some sections the ¼ gallon application lasted throughout the season, while in others a second application was necessary. There is a cumulative effect with each additional application, so that after two or three years, it is expected to build up an asphalt impregnated top layer, which will make a good surface under moderate traffic. This is not intended to be the ultimate surface, but simply a satisfactory means of maintenance. Shale-bound gravel surfaces have been treated in the same manner and with equally good results. No cover coat is used in this work, the road bed being graded and dragged immediately before the application of the oil, so that a loose covering ½" to 1" thickness is obtained. The oil penetrated this covering very rapidly, and within a few days had completely dried and ironed out. Any holes appearing, are patched with untreated shale, and the entire road graded before a second application is made. It is appreciated that this method is somewhat at variance with practice elsewhere, especially with reference to cover coat, but it works under our conditions, and a large mileage will be treated in 1926. The traveling public has been much pleased with this method of treatment.

In conclusion, I wish to stress the following points:

1. That it is an economic mistake to tear up and throw away old macadam and gravel roads, when through the addition of new stone and a bituminous top, they can be salvaged and made to give satisfactory service.

2. Every possible use should be made of local resources, instead of blindly following old methods, and importing materials to comply with some set specifications. Asphalt lends itself to such a variety of uses, that many materials not previously considered, are proving to be valuable road surfaces when properly treated.

3. The public in general, does not care of what roads are made, provided they are smooth, travelable at all seasons and times, and are safe. Asphaltic types have met these demands at reasonable cost, and continue to grow in public favor. Such types make up the larger portion of West Virginia mileage.

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The Business Situation

THE business news of the past few weeks has been somewhat mixed in nature, and it will be necessary to wait until more of the figures of industry and commerce are available before any true estimate can be formed of the developing trend of affairs in this new year.

The most important favorable item is the fact that the total value of the checks being handled by banks is higher than ever before, which indicates that the current volume of trade, after allowance for seasonal variations, is at the highest levels ever reached. It is probably true, however, that many of these checks are in settlement for purchases made in connection with the holiday trade which is now a matter of past, rather than current, business.

Other favorable items include the good January business of the mail order houses, and the large output of automobiles last month. The mail order business was well above the estimated normal, although the gain in this past January over that of last year was smaller than the December gain over that of 1924. Automobile output in January was nearly 334,000, which was a large increase over that of the first month of 1925, but a small advance beyond the January production of 1924.

The most important unfavorable item of business news is that wholesale prices showed a decline at the beginning of February, and they have now moved slowly downward for three months in succession. It is also true that the demand for iron and steel has been less in the past few weeks than was expected, and the car loadings on the railroads have declined somewhat. In summary it should be noted that general business is very good despite the fact that the important elements just referred to are not so fully reassuring as they were up to a month ago.

Iron and Steel

Iron and steel markets have been characterized since the first of the year by some contraction of demand, easier prices for a few products, and slightly less active operations. The development is in keeping with the lassitude which frequently appears in the steel trade in late January and early February. During last month, buyers disclosed pronounced reluctance in making forward commitments. Shipments exceeded fresh orders and, at the close of the month, many mills found that their order books were thinner than they had been one month before.

In addition to seasonal influences, the market has been retarded by the prevailing feeling among consumers that high outputs and efficient railroad deliveries give assurance of ample supplies. By the same logic, price advances are not expected. Decided resistance to quotations has developed from buyers, led by automobile producers. This has resulted in a state of deadlock in some instances, and a number of producers, particularly in the Mahoning Valley, have curtailed operations. However, since the first of February a few large automobile companies have succeeded in obtaining automobile sheets at $3 to $4 a ton below the open market rates.

Average prices are a shade lower than they were at the beginning of the year, reflecting small declines for sheet bars, pig iron and a few other products. The level of prices is about 5 per cent below its position 12 months ago, but it remains more than five per cent above the lowest point touched last summer. Because the direction of scrap price movements frequently forecasts iron and steel quotations, the recent weakness of scrap is significant.

The real test of the probable spring demand for steel has not yet appeared. Automobile companies are increasing outputs, but are inclined to feel their way with the development of seasonal selling. Building construction is still held back by weather conditions. The railroads are feeding out inquiries and orders on a larger scale than last year, but without any semblance of a rush. Freight car awards in January were 8,800 compared with 16,000 in December and with 1,700 in January of 1925. The roads, with more than

300,000 idle cars, are under no urgent pressure to place orders. Farm implement manufacturers expect that their business in the first half of 1926 will exceed that of the corresponding period last year by 15 per cent.

The iron and steel trade has been affected by the hard coal strike. The protraction of the mine tie-up has caused prices for furnace coke to soar to extraordinary levels, due to the demand for coke in the east as a substitute for anthracite. This situation has caused a slackening in blast furnace activities. During January, 10 furnaces suspended operations, some of them finding it more profitable to offer their supplies of coke on the open market than to make pig iron. At the close of the month 224 furnaces were in blast, being 58.2 per cent of the total, compared with 60.7 per cent one month before, and with a theoretical normal of 60 per cent.

Col. Leonard P. Ayres, Cleveland Trust Company, February 15, 1925.

Industrial Conditions

The steadiness of business today has been based on the approximately even balance between industrial production and consumption. There are signs now that production is speeding up so that it will, in the not distant future, produce a slight excess of manufactured goods of certain kinds unless there is a corresponding increase in consumption. Expansion of production, as we have often previously pointed out, is generally an accompaniment and the last upward phase of the business cycle. Ordinarily, it would have occurred at a point in the present move, which was reached early in 1925. Conservatism and good judgment on the part of business men prevented it from taking place then. We believe that the present indicated increases in production are likely to have been based on very careful sales forecasts and owing to scientific inventory control and most efficient transportation facilities, the move can be checked sharply if at any time the sales forecasts prove to have been too optimistic.

Domestic consumption is, of course, based on the prevailing level of individual prosperity. This at the present time is high. Labor is quite fully employed and at wages which seem satisfactory to both capital and labor, although a slightly increasing tendency on the part of labor to demand increases has been noticeable in the last month. The experience of the anthracite miners should prove to be an adequate restraint against drastic action on the part of labor. The railroad labor demands for increases are, of course, excessive, but probably made to establish a trading position. The new machinery established to handle such demands should prove entirely effective to making an award fair to both sides, probably in the nature of a percentage increase which it will be entirely within the ability of the carriers to meet.

There are no signs of over-speculation in commodities; also a usual forerunner of a period of depression. Indicated over-production of cotton, corn and sugar is apparently being balanced to a large extent by increased consumption. Oil production has been steadily declining. Stocks accumulated during the flush period last summer are being drawn down somewhat. Increases have been posted in various fields and more are in prospect. The outlook is for a prosperous year for oil companies of established production.

But there is a factor which is already beginning to undermine confidence to a degree and which, unless checked or corrected, can considerably accentuate and hasten the next trade recession. This factor is the attitude of politicians and the radical press toward business. It may not be fair to include the activities of the Federal Trade Commission with the former. The actions instituted by the Commission are probably sincere and may have been begun only after careful investigation, although the National Food Products incident makes this latter point doubtful. However, in the cases of various members of the House and Senate, speeches are being made both in and out of Congress, and bills introduced which are tending to bring business into disrepute in quarters where it is not understood that they are made entirely for political motives based on selfish reasoning and without true understanding, knowledge or regard for actual facts. The radical press, believing that circulation is among the masses and that anything adverse to capital or big business appeals to the masses, gives these outpourings the widest possible publicity. The cumulative effect of which is to make business men afraid that there will be unwarranted governmental interference with their activities.

Goodbody & Co., New York, February 17, 1925.

Prices and Money Rates

The general trend of commodity prices has been downward since the first of the year. A moderate downward tendency has been visible also in money rates, though the decline appears to have been checked in the last fortnight. In fact, call loan rates have moved upward, while time loan and commercial paper rates have remained firm since the beginning of this month, but at a level perceptibly below that of the closing weeks of 1925.

The initial reports of the New York Stock Exchange and the Federal Reserve Board on loans to brokers show a total volume of credits based on security collateral considerably in excess of the advance estimates, although their exact significance is doubtful in the absence of any definite basis of comparison.

Last month's foreign trade marked a resumption of the merchandise import balance which has been an intermittent feature of trade reports in the last three years. The excess of imports in last month's trade was in line with the general tendency toward a closer balance of merchandise shipments which has been evident since 1921. It was, however, the only actual import surplus of any considerable size since the spring of 1923. In July, 1924, and again in June of last year, imports exceeded exports, but only by a nominal amount in each case.

The Coal Situation

The sudden termination of the strike in the anthracite mines removed one of the major sources of anxiety respecting the immediate future of business in this country. Although the cutting off of the supply of hard coal presented no serious threat of a shortage of industrial fuel, a total suspension of operations in an industry of such magnitude could not fail to exert an adverse influence in many directions.

The terms of the agreement represent concessions by both sides. In its main features, the plan represents as constructive a solution of the problem as could have been expected. It permits a resumption of operations without an advance in the costs of mining and without the objectionable expedient of public intervention or control. It provides, moreover, a method of arbitration ingeniously devised to secure impartiality and to make further suspensions within the five-year period, if not impossible, at least highly improbable.

It should be noted, however, that the increase in the personnel of the board of arbitration, in the event of a deadlock, is optional. In order to effect such an increase, both members of the original board would have to agree on the new appointee or appointees. It is reasonable to suppose that the member opposing the modifications under discussion would vote against the increase, thus preventing the adoption of the proposed change by a majority vote. To this extent the plan fails to provide an absolute guarantee against the possibility of strikes.

In the long run, the anthracite strike will undoubtedly prove to have had little effect on the situation in the soft-coal industry. The old problems of over-expansion and high union wage scales will have to be confronted anew. The conditions of the last six months, however, have provided a measure both of encouragement and of financial relief. And some permanent enlargement of demand may result from the enforced changes in consumers' habits during the strike.

Guaranty Trust Co., New York, Feb. 23, 1925.

Items of Interest

Research Fellowships in the Institute of Research, Lehigh University, Bethlehem, Pennsylvania

On or before June 1, 1926, the Institute of Research of Lehigh University will appoint three research fellows, as follows:

1. One New Jersey Zinc Company Research Fellow in Science and Technology for the period of two academic years beginning September 1, 1926, with an annual stipend of $600. Half of the time of the holder of this Fellowship must be devoted to research work in the field of science or technology to which he is assigned; the other half to graduate study leading to the degree of Master of Science at the end of the two year appointment.
2. Two Henry Marison Byllesby Memorial Research Fellows in Engineering for the period of two academic years, beginning September 1, 1926, with an annual stipend of $750. Half of the time of the holders of these Fellowships must be devoted to research work on some problem in electrical, mechanical or hydraulic engineering, proposed by the President of the Byllesby Engineering and Management Corporation and approved by the Institute of Research; the other half to graduate study leading to the degree of Master of Science at the end of the two year appointment.

Applications for appointment to these Fellowships may be submitted before May 1, 1926, by graduates in engineering or science of colleges, universities or technical schools whose requirements for graduation are substantially the equivalent of those at Lehigh University.

Applications or requests for additional information should be addressed to Charles Russ Richards, President, Lehigh University, Bethlehem, Pa.

New Resistance Welders

In resistance welding, fusion is effected by heat generated by passing an electric current through the materials to be welded, augmented by pressure, whereas arc welding utilizes an arc or flame to melt the work, electrode or both. Automatic resistance welders consist of a framework for holding the work, a transformer for supplying current to the electrodes, movable electrode wheels and necessary control.

These equipments were particularly designed for welding the seams of light metal containers such as ice cream cans, drums, etc., and are suitable only for making lap joints with relatively thin metal. Among the advantages are the absence of fumes and open arcs making the use of masks unnecessary, and the fact that the operator requires no special welding training. The welding speed obtained with these equipments varies from approximately 20 inches per minute to 100 inches per minute, depending on the nature and thickness of the material to be welded. Material up to a total thickness of ¼ inch may be accommodated.

STRUCTURAL MATERIALS RESEARCH LABORATORY

Studies of Bond Between Concrete and Steel

Bulletin 17, by Prof. Duff A. Abrams has just been published.

Bond tests were made by applying a pull on one end of 1-in. plain round steel bars embedded axially in 8 by 8-in. concrete cylinders; parallel compression tests were made on 6 by 12-in. concrete cylinders. The concrete covered a wide range in quantity of mixing water, cement, and size and grading of aggregate. Tests were made at ages of 7 days to 1 year. 735 pull-out bond tests and 735 parallel compression tests were made.

The principal conclusions from the tests are:

(1) Slipping of the bar began at a bond stress of about 10 to 15% of the compressive strength of the concrete, but considerable additional load was taken before the ultimate bond resistance was reached.

(2) An end slip of bar of 0.0005 in. occurred at 55 to 60% of the maximum bond. For mixtures leaner than 1-1, the maximum bond was about 24% of the compressive strength of the concrete and came at an end slip of about 0.01 in. regardless of the characteristics of the concrete.

(3) Bond and compressive strength increased with age of the concrete from 7 days to 1 year. For 1-5 concrete of water-ratio 0.88, the bond at 1 year was 134% of the 28-day value and the compressive strength was 148%.

(4) Bond responded to changes in water-ratio of the concrete in much the same way as compressive strength; increase in water-ratio due to use of wetter concrete, less cement, or an excess of fine aggregate, resulted in material reductions in both bond and compressive strength.

(5) For mixtures richer than 1-1 the bond fell off, probably due to the greater volume changes during hardening, which is characteristic of such mixtures.

(6) The use of 4% of the 28-day compressive strength of concrete as the working stress in bond for plain bars, as specified by the Joint Committee, is justified; this gives a factor of safety of about 2½ to 3 against first slip.

(7) The use of crude oil to replace mixing water, in general, caused a reduction in both bond and compressive strength of concrete due probably to the lubricating effect of the oil. Replacing cement with hydrated lime also decreased the compressive strength and bond about 1.2% for each 1% of hydrated lime in terms of volume of cement or about 2% for each 1% by weight.

DOMINION WATER POWER & RECLAMATION SERVICE, CANADA

Hydro-Electric Progress in Canada During 1925

Hydro-Electric and water power development in Canada reached record proportions during the year 1925, the increase in the total installation far exceeding that of any previous year. No less than 719,000 h. p. was added during the year, bringing the total installation in the Dominion to 4,290,000 h. p. Many projects are also under way which will add more than 250,000 h. p. in the early part of 1926.

1925 was of outstanding interest, not only on account of the large increase in installed capacity, but also because it marked the bringing into operation or completion of a number of large projects which have been under active construction for the past few years. Of these the most notable are the Queenston development of the Ontario Hydro-Electric Power Commission on the Niagara river with 500,000 h. p. completely installed, and the development of the Duke-Price Power Company on the Saguenay river in Quebec which brought into operation 360,000 h. p. of an ultimate capacity of 540,000 h. p. While the next year or two are not expected to witness as large increases as 1925, there are projects of great magnitude now under way or in early prospect which will provide substantial additions as they are brought into operation. These include the 800,000 h. p. development recently commenced at Chute à Caron on the Saguenay river by the Aluminum corporation of Canada and a project of almost the same ultimate proportions on the Bridge river by the British Columbia Electric Railway Company.

By provisions, Quebec led with a total installation of 438,300 h. p. largely contributed by the development of the Duke-Price Power Company. Ontario followed with almost 200,000 h. p. contributed chiefly by the Queenston development of the Ontario Hydro-Electric Power Commission. Other provinces having important additions were British Columbia with 58,984 h. p. and Manitoba with 21,900 h. p.

BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON

Properties of Cement-Lime Mortars

An increase in workability and possible reduction in cost are the principal reasons why lime might be used to advantage in cement mortars. When lime plaster is gaged with cement, it still retains considerable of its former workability, and has gained in strength, while the time of set is reduced.

In this work the Bureau found that when cement paste and lime paste were brought to the same consistency, a much greater percentage of water was required by the lime than by the cement. With this relation holding, the percentages of mixing water in cement mortars and in lime mortars increased with a decrease in the percentage of sand. A cement mortar with lime added requires extra mixing water, but this extra water increases shrinkage possibilities, therefore lime should be limited in cement mortars where it is desired to keep shrinkage low. It is possible to keep shrinkage low by the use of a high percentage of sand in any mortar.

The density of lean cement mortars may be increased by the addition of a small percentage of lime. Where the cement mortar is not richer than 1:2, the addition of lime may result in increasing the strength. The percentages of lime which may result effectively in these respects were found to increase with the leanness of the mortar. It is probable that the lime does more than act as a void filler in lean cement mortars, for it can carbonate and form a binder in the place of the missing cement.

It is not to be expected that these results will be duplicated exactly where other brands of materials or differently-graded sands are used with different manipulation and under different storage conditions.

Wind Pressure on Model of Building

The average wind pressure on a tall building when the wind is blowing at 76 miles per hour (100 miles per hour, as shown by a Weather Bureau, Robinson type anemometer) is about 22 pounds per square foot. The value which is commonly used is 30 pounds per square foot. This would correspond to a true wind speed of about 88.5 miles per hour (118 miles per hour indicated speed). Gusts of this speed have been observed only in a few cities, such as New York and St. Paul.

These results were obtained by measuring the force of the wind on a model of a tall building mounted in the large outdoor wind tunnel of the Bureau. This tunnel is 10 feet in diameter, and in these experiments winds up to 70 miles per hour were produced, values for higher speeds being obtained by extrapolation. By means of small openings in the face and top of the model which were connected to a pressure gauge, the pressures produced by the wind at various parts of the structure were measured. These measurements were made at 70 places on the face of the model and at 49 places on the top, with the wind coming from 13 directions, varying from directly against one face to directly against the opposite face. Of course, in this work the wind always comes from one direction, and the model is turned on its mounting. The pressures obtained were then multiplied by the appropriated areas to give the total force on the model under the different conditions. The forces tending to overturn and to twist the model were also computed.

This work was undertaken because of the many inquiries received by the Bureau concerning wind pressures on buildings. The same experimental methods were employed which have been found so useful in the investigation of air forces on airplanes.

It has always been recognized that in the design of engineering structures such as tall buildings, bridges, chimneys, transmission lines, radio masts, etc., it is necessary to make provision for the stresses produced by the pressure of high winds. However, the values of the forces produced by the wind used by engineers in structural design are based on experiments made a great many years ago by methods which are now known to be subject to large errors, and on models which do not resemble actual structures. Many engineers have felt that these old values are too large, and that many structures are made stronger than is necessary, and therefore cost more than they should.

The Bureau has determined the actual pressure corresponding to a given wind velocity. There still remains the problem of determining what wind velocity to use in designing a structure. Obviously, a higher velocity ought to be assumed in designing a building facing the lake front in Chicago than for a building in the downtown section of Washington.

Deflection of 40-Inch Brick Wall Under Pressure of One Finger Can Be Measured

The amount of deflection of a brick wall 40 inches thick under the pressure of one finger can be measured by an instrument recently constructed by C. G. Peters of the Bureau. If one looks into the eyepiece while some one else walks across the floor the deflection is apparently so great that one would suppose the whole building to be swaying back and forth as though made of cardboard.

The instrument makes use of the interference of light waves, and is very simple in construction. A glass plate is fastened to the wall of the building. Another plate is mounted close to this first plate in the tube of the instrument. Part of the light from a helium tube passes through the plate in the instrument and is reflected back by the plate on the wall into the eyepiece. The remainder is reflected directly from the plate in the instrument. The interference of these two sets of light rays causes light and dark bands to appear in the field of the eyepiece. When the distance between the two plates is changed the bands move across the field. Motion equal to the distance between two dark bands represents a deflection of about one one-hundred-thousandth of an inch.

NATIONAL INDUSTRIAL CONFERENCE BOARD, INC.

Report on the Inequality of the Farmer's Economic Position

While farm land acreage increased faster than the population up to 1860, the acreage of farm land per inhabitant since then has decreased 30 per cent. Improved acreage continued to increase faster than population up to 1880, but per capita acreage of improved farm land has decreased by about 16 per cent since that time. The acreage of harvested crops increased faster than the population up to 1900, but crop acreage since 1900 has decreased about 8 per cent per capita of population. In addition, the yield per acre of principal crops, which had increased rapidly until about 1900, has declined by about 4 per cent since. Thus, farm production in proportion to urban population has been decreasing since 1880, and has declined by 20 per cent since 1900 alone. Since 1900, farm exports show a distinct downward trend, while agricultural imports are increasing.

The farmer's weakened position in meeting foreign competition has resulted from a tendency of his expenses to rise more rapidly than the price he receives for his products. Overhead capital costs, including all taxes and interest charges of farming, which rose less than 60 per cent from 1880 to 1900, increased about 100 per cent from 1900 to 1910, and nearly 600 per cent between 1900 and 1920. Farm labor costs, in the 20 years, increased 90 per cent. Operating costs per unit of production, covering all materials and products of other industries purchased by the farmer, practically unchanged between 1880 and 1900, rose 116 per cent between 1900 and 1920. Combined costs per unit of product rose over 300 per cent in these twenty years. But wholesale prices of farm products increased only 120 per cent during the same time.

The return on the total capital invested in agriculture, including the value of the food, fuel and shelter supplied by the farm, during the five years prior to the World War averaged 5½ per cent but, during the five years since 1920, averaged only 4 per cent and the net return on the individual farm operator's investment averaged only 2 per cent. The average return to the farmer for his labor and management, after allowing a nominal return on capital invested, including the food, fuel and shelter supplied him by the farm, in the five years preceding the war, averaged $470 a year; in the five years since 1920, $600 a year. But taking into account the increase in the cost of living for the farmer, the purchasing power of his annual income since 1920 is about 4 per cent below that earned by him in 1914.

Actual earnings of the farmer in 1924 in return for his labor are computed at $730 on the average, as against average earnings of $1,256 per wage earner in the manufacturing industries in the same year, average earnings of $1,572 by transportation workers, $2,141 earned by clerical workers, an average of $1,678 earned by ministers, $1,295 by teachers, about $1,650 by government employees, and an average of $1,415 per worker in all groups other than farmers. The food, fuel and housing, supplied by the farm, is appraised at about $630 per year, which leaves the average farmer a cash income of about $100 out of the $730 earned by his labor during the year 1924. An average return of about $400 is allowed on the capital invested, making the total average cash income per farmer operator about $500 a year. Since the cost of food and clothing purchased by the average farm family during the year runs to about $475, the average farm income is only slightly more than enough to purchase the necessities of life.

In summing up the causes of the farmer's difficulties, while 60 per cent of the farmer's income depends on world conditions of supply, demand and costs, which are out of his control, most of the elements entering into the expense of operating the farm, that is the cost of agricultural production, are determined by domestic conditions which place the costs for the farmer on a higher level of values than the world level of values which determines the bulk of the farmer's income. Having to produce at a level of high costs, the farmer must meet competition which, producing at lower cost, limits the market for his surplus in accordance with the abundance or scarcity of world crops.

Extraordinary Growth of State and Local Bonded Indebtedness

Simultaneously with the growth in taxation, there has been a constantly increasing volume of public borrowings by state and local governments. New bonds issued by them in 1925 totalled $1,391,000,000, or only a little less than the record figure reached the preceding year, when the total was $1,399,000,000. The ten-year average of such public loans during the decade just before the war was about $302,000,000 or

$20,000,000 less than the annual interest charges on the new state and local government bonds issued since 1913. Taking into account the decrease in purchasing power of the dollar and the increase in population since 1913, new indebtedness incurred yearly by state and local governments, computed in dollars of 1913 purchasing value and per capita, during the past five years has averaged still 40 per cent higher than their total borrowings in the last year before the war.

The total net indebtedness of state and local governments at the end of the year 1925 is estimated at $11,650,000,000, as compared with $8,697,000,000 at the end of 1922, and $3,822,000,000 in 1913, showing an increase in the net indebtedness of 34 per cent since 1922, and of 205 per cent since 1913.

The total expenditures of state and local governments in 1923 amounted to an equivalent of $58.71 per man, woman and child in this country. Out of this total, $16.69 per capita went for education and libraries, $12.03 for highways, $9.69 for interest and amortization charges, $3.97 for protection of persons and property, $2.83 for general health and sanitation service, $3.24 for administration and general government expense, $2.74 for charities, hospitals and correctional institutions, $1.00 for recreation, and $3.60 for public service enterprises.

Results from Industrial Medical Supervision

While the policy of industrial medical supervision has been more extensively developed in the United States than in any other country in the world, its potential value can be appraised only if it is realized that as yet American wage earners lose in wages through absence due to illness approximately $250,000,000 a year. The loss to the workers in wages, however, is only part of the economic loss involved. Industry loses by decreased output and increased labor turnover; trade losses, through the worker's decreased purchasing capacity, and every consequence of illness, cultural, physical and economic are reflected in the diminished health and happiness of the community life.

The economic loss caused by illness is exemplified by the experience of one typical New England plant employing an average of 4,500 workers. Illness at one time or another during one year, averaging 1½ weeks per employee, cost the company in lost time, transfers and lay-offs, and reduced production on part of those working but not in good health, a total of $267,500; the workers lost a total of $202,000 in wages, spent another $45,000 in medical, surgical and nursing expense, while their disabilities entailed another $56,000 of expense in charitable relief and care, a total loss to the community of $570,500 in one year's time.

Among 500 industrial plants investigated, 447 reported total annual expenditures of more than $5,000,000 for medical service rendered to their employees, yet the average annual expenditures amounted to only $1.03 for each $1,000 worth of products, or $3.62 for each $1,000 paid out in wages. To indicate, in a measure, the results obtained by medical preventive measures and supervision, the records of one plant show that, out of the total time lost because of illness, nine-tenths was lost by those employees who had not availed themselves of the medical facilities provided. They constituted one-fifth of the total number reporting ill.

Cold Weather Mortar

Eight lime and Portland cement mixes and four bricklayers' cements were recently tested at the University of Wisconsin for shear, tensile and compressive strengths after curing in warm and cold storage. From these tests a lime-cement mortar composed of one part cement, two parts lime and nine parts sand was recommended for winter use. Strength, workability and economy requirements are all fulfilled by this 1:2:9 mortar which, although it contained twice as much lime as cement, was almost as strong as straight Portland cement mortar in warm storage and held its strength in cold storage. It showed an increase in strength of over 300 per cent in cold storage, a gain greater than any other mortar tested.

The exceptional combination of advantages possessed by this mix makes it ideal for cold weather use. It is low in cost. The materials are readily available in all sections of the country, and may be purchased under standard A. S. T. M. Specifications. With building operations being carried farther into cold weather with profit to the contractor, convenience to the owner and an extended season of employment for the workmen, the findings of the tests conducted at the University of Wisconsin are most timely.

Analyses of Crude Petroleums

A study of the properties of typical crude oils from the producing fields of the western hemisphere has been made by the Bureau of Mines, Department of Commerce. A report on the subject, just issued, includes comments, tabulated data, and individual analyses of crude petroleums typical of the producing districts of Canada, Mexico, Trinidad, Venezuela, Argentina, Colombia, and Peru. For purposes of comparison, the report also contains analyses of typical crude oils from the largest producing districts of the United States.

The results of this survey are contained in Technical Paper 346, by A. J. Kraemer and L. P. Calkin, copies of which may be obtained from the Bureau of Mines, Department of Commerce, Washington, D. C.

Diesel Locomotives*

By SAMUEL M. VAUCLAIN

President, Baldwin Locomotive Works

IN applying the Diesel heavy oil engine to true locomotive units, the first consideration must be that of "weight per horse-power developed." The heavier classes of Diesel engines in stationary service weigh within a range of 170 lbs. to 350 lbs. per horse-power. In locomotive service the weight of Diesel engine must be added to the weight of transmission, running gear and vehicle body. If a 1,000 horse-power Diesel engine of 170 lbs. per horse-power is used in a locomotive, its weight of 170,000 lbs. would exceed the total weight of a complete steam locomotive of like capacity. During the great war some Diesel engines for submarine service were built showing a horse-power for every 65 lbs. of engine weight. The locomotive designer needs this type of machine.

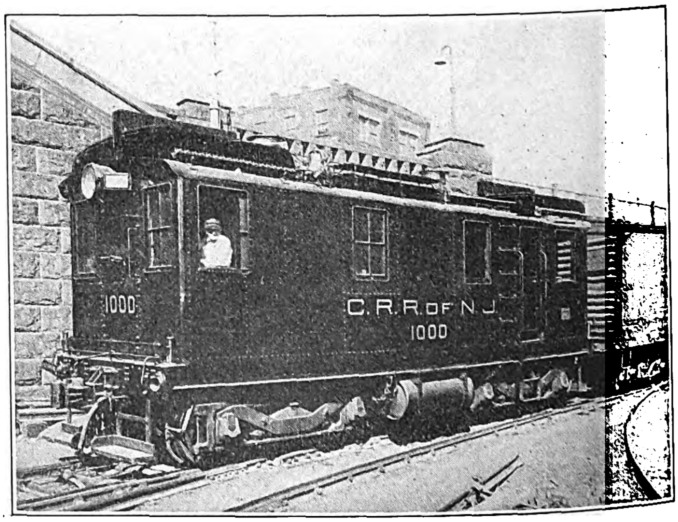
The 1,000 horse power rated Diesel-electric locomotive built in Germany for the Russian Railways (1924) has a total weight of 275,000 pounds; 275 lbs. per horse-power. The 1,000 horse-power rated Diesel-electric locomotive built in 1925 by The Baldwin Locomotive Works also weighs 275 lbs. per horse-power. This indicates a close coincidence of best European and American practice and sets for the present this weight per horse-power for modern Diesel-electric locomotives. A slight decrease in weight can be looked for with an advance in locomotive horse-power, and the present expectation in this respect is about 220 lbs. which represents a ratio of about 1 to 1.5 when compared with an average steam locomotive. With a thermal efficiency of 3 to 1 in favor of the Diesel engine it appears that the added weight per horse power is not a severe handicap. Ratios of this character, provided they go hand-in-hand with simplicity, should show attractive operating economies. What then should be the features tending toward simplicity of maintenance?

In the discussion of this phase of the design of the true locomotive units (not self-propelled cars) it is advisable to review the history of internal combustion locomotives. In such a review it will be found that the means of coupling, or transference of power from the prime mover to the driving wheels, has been found of greatest importance. The first real Diesel locomotive was that designed in 1909 by engineer Adolph Klose, of Berlin, and constructed jointly by Sulzer Brothers of Winterthur, Switzerland, and Borsig of Berlin-Tegel, Germany. To show the boldness of the design, which was of 1,000 horse-power, it should be compared with what is believed to be the first internal combustion locomotive ever constructed, the Daimler engine of 1891. As Dr. Diesel's oil engine had not at that time been invented, the prime mover was one of the earliest types of internal combustion motor and developed only 4 horse power.

Inasmuch as the Diesel (or other internal combustion) engine must be operated at speeds within its range of efficiency and not at a practically zero start as in direct connection, the designer must find proper means for connecting the running prime mover to the locomotive driving mechanism. This transfer of power can be accomplished in three ways:

1. By mechanical (stepped gearing) transmissions.
2. By hydraulic (fluid pressure) transmissions.
3. Transmission of power by electricity.

Recent internal combustion locomotive construction in the United States has been only along the line of electric transmission. The General Electric Company built in 1924 a "gas-electric" engine of 175 horse-power for use around their Pittsfield Works. In 1925 a 300 horse-power Diesel-electric engine weighing 60 tons (400 lbs. per horse-power) was built jointly by the General Electric Company, The American Locomotive Company and The Ingersoll-Rand Company, the last mentioned concern manufacturing the Diesel motor used as the prime mover. After tests in the yards of its builders, it was experimently exploited on several of the railways in the vicinity of New York City. The same combination of manufacturers has since built, for the Long Island Railroad, a similar machine of twice the power; its power plant being arranged as twin units, parallel within the cab. This later machine weighs 100 tons (333 lbs. per horse-power). It is now in preliminary operation on the



300 HORSE-POWER G. E.-INGERSOLL-RAND ENGINE

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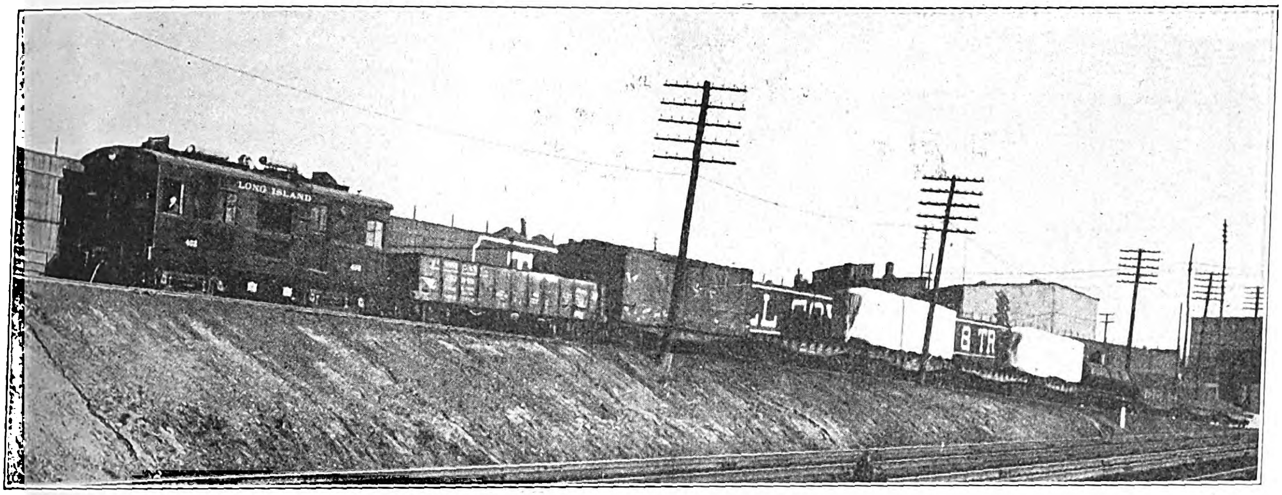
*Portion of an address January 29, 1926, by Mr. Vauclain before the Mid-West Power Conference at Chicago, Ill.

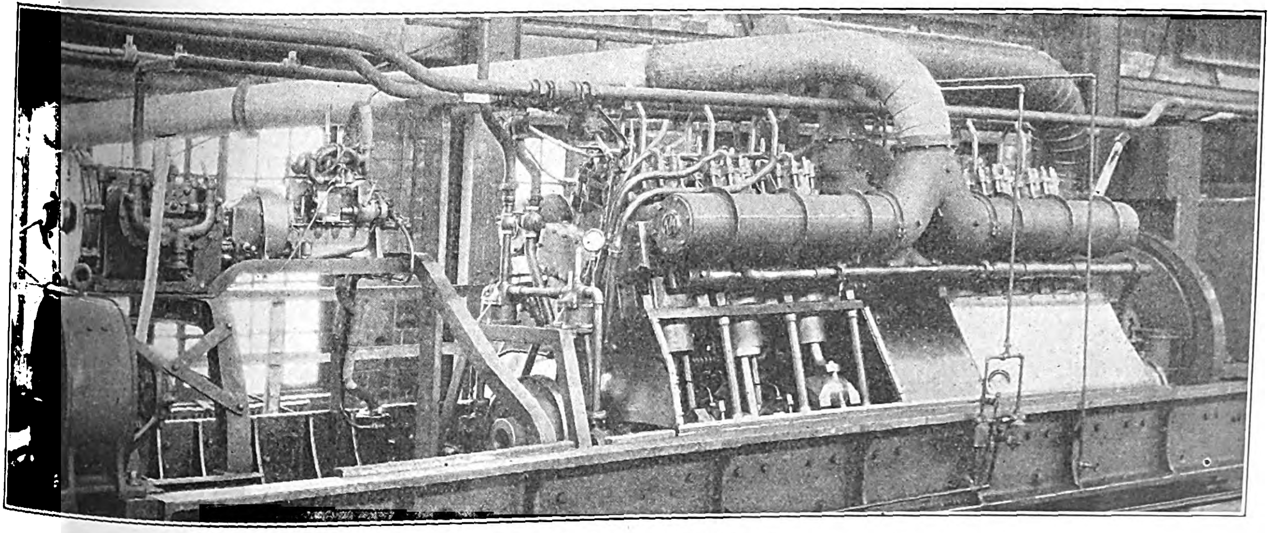


BRILL 500 HORSE-POWER "GAS-ELECTRIC" LOCOMOTIVE

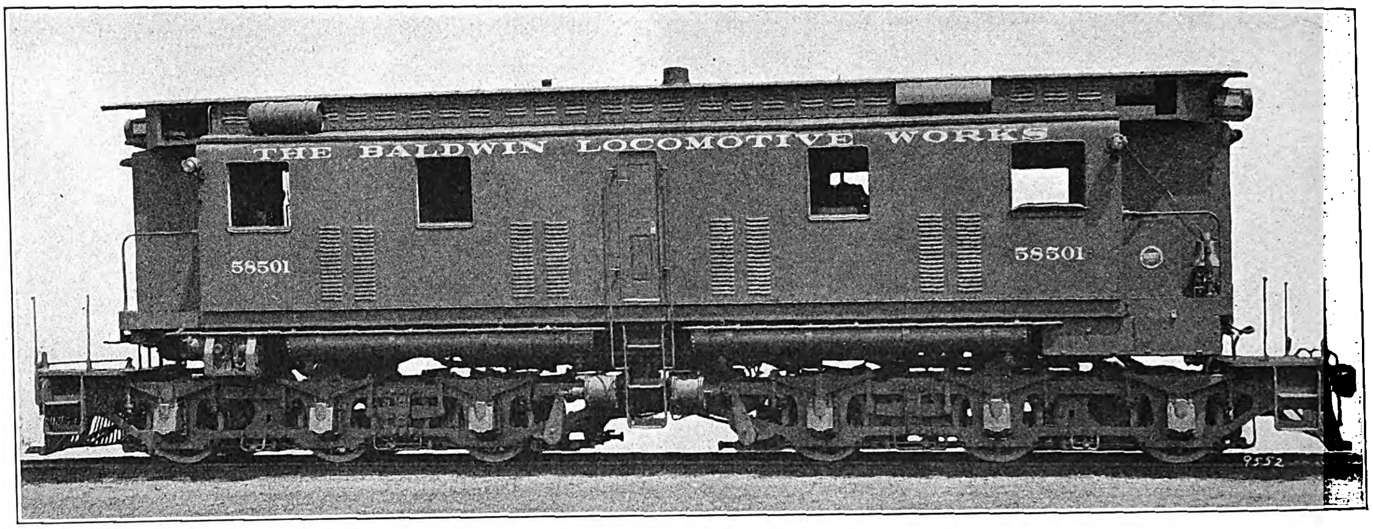
Long Island Lines. Comparison of this machine will shortly be made with a "gas-electric" locomotive built by the J. G. Brill Company for the same railroad. This engine weighs 75 tons (300 lbs. per horse-power) and is equipped with twin power plants, each consisting of a 250 horse-power gasoline engine coupled to a generator of 160 K. W. capacity. The comparison of heavy oil and gasoline motors in the same class of service and on the same railroad will furnish very interesting data.

In 1925, The Baldwin Locomotive Works produced a Diesel-electric locomotive of 1,000 horse-power, the prime mover for which is a two-cycle, solid injection engine of peculiar construction and very light weight. This machine represents the largest unit ever attempted in the United States. It is the result of extensive research and experimentation to fulfill the requirement of a reliable self-contained unit of simplest possible ensemble and ease of control. This locomotive weighs 275,000 lbs. (275 lbs. per horse-power) and is mounted on two six-wheeled trucks having traction motors applied to four of the six axles. Its electrical equipment is of Westinghouse manufacture, with electro-pneumatic and magnetic controlling mechanism arranged for double-end operation. The Diesel engine is of the inverted "V" type with twin crank shafts geared to a central shaft on which is mounted the electrical generator. This locomotive is now undergoing intensive tests at the yards of its builders and on adjacent railway lines.

It is the opinion of your speaker that considerable time must elapse and many millions of dollars be expended in the development of an "oil-electric" power unit in the shape of a locomotive before machines of this type will figure to any great extent in transportation service. It has many apparent advantages that are not only of great interest to railway men, but also very seductive even to those who do not clearly understand all that is involved. You will have noted that at the present time construction costs are practically as two-to-one compared to steam power. We have all the same thought:—If a machine as service-



POWER PLANT OF BALDWIN ENGINE



BALDWIN 1000 HORSE-POWER DIESEL-ELECTRIC LOCOMOTIVE

able as the present steam locomotive and one that can be as economically maintained in service can be produced, then great relief and resultant economy will be obtained by the elimination of ash pits, the various ash-handling devices connected therewith, and the necessity for transferring refuse, as well as much of the periodical attention required to keep the ordinary steam locomotive in proper condition for service. I might also mention the satisfaction that the elimination of boiler troubles and explosions will bring to those men responsible for railroad motive power, even though such anxieties have been almost entirely removed by proper regulation of the maintenance and use of locomotives. The only accidents now being recorded are those due to the personal equation, and these, it is human experience, can never be entirely overcome.

The internal combustion locomotive unit, whether constructed with direct drive, hydraulic transmission, or electric transmission, is yet in its infancy. The best engineering talent of the world is bending its energy to a successful solution of the problem, and we will not know what new difficulties in operation will be encountered or what the anxieties of the future may be in the matter of safety until the actual operation of some appreciable number of engines gives us a thorough experience.

The introduction of electric power for transportation purposes has been slow. The expense of installation and the general inconvenience and obstruction incident to its application in service yards and large railway terminals have militated against it; but step by step it has progressed and become a necessity for all underground transportation, or for increasing the volume of traffic over such sections of railway as are difficult of operation and on which the use of steam locomotives has reached its limit.

If it will be possible for those of us who are engaged in the development of internal combustion locomotives to produce a satisfactory machine at a satisfactory price to the purchaser, its greatest effect upon the transportation methods of the country will be to further the electrification of railways in general. This experiment is now being tried in Switzerland, and if by the use of internal combustion locomotives all branch line service as well as all distributing service at railway terminals, both large and small, can be satisfactorily accomplished, and only main line service by overhead wires or third rails be required, we can then expect a more rapid development in the electrification of our railways. But it will be many years before the steam locomotive, owing to its simplicity, its serviceability and its low production cost will be relegated to the era of the past.

C. R. R. of N. J.—Actual Results

The following statistics are from actual operating records:

COMPARATIVE OPERATION

During the month of December

1925—Ingersoll-Rand 60-Ton Oil-Electric Locomotive

1924 Steam Locomotive

	1925	1924
Number of days	24	24
Hours of locomotive service	347	297
Operating fuel consuming hours	318	297
Fuel oil used, gallons	1,038	
Diesel lubricating oil used, gallons	25	
Gasoline used	5	
Engine oil used	5	5
Valve oil used	10	5
Star cup grease used, lbs.	1	
Kilowatt hours generated	6,614	

Coal used, tons		41
Number of float's handled, in	57	47
" " " " out	57	46
Total	114	93
Number of cars handled, in	947	775
" " " " out	943	765
Total	1,890	1,531
Tons handled, off float (net 19,908)	38,889	31,040
" " on float (net 3,766)	22,667	19,453
Total (net 23,674)	61,556	50,493

(Includes tare weight of cars.)

Cost of Operation:

Fuel oil at $.05 per gallon	$ 51.90	
Diesel engine lub. oil $.53 per gal.	13.25	
Gasoline at $.145	.72	
Water at $.01/10 cu. ft.	.03	28.37
Engine oil at $.262 per gallon	1.31	1.31
Valve oil at $.53 per gallon	5.30	2.65
Star cup grease at $.07 per lb.	.07	
Coal cost at $7.15 per ton		293.15
Coal cost handling		24.00
Total cost of fuel, coal, oil, etc.	$ 72.58	$349.46

DAILY OPERATING AVERAGE

	December Oil-Electric 1925	Steam 1924
Hours of locomotive service	14.5	12.4
Operating fuel consuming hours	13.3	12.4
Fuel oil used, gallons	43.2	
Diesel lub. oil used, gallons	1.04	
Gasoline	Neg.	
Coal used, tons		1.7
Kilowatt hours generated	275	
Number of floats handled	4.75	3.87
Number of cars handled	79	64
Number of tons handled	2565	2104
Cost of fuel, oil, coal, etc., total	$ 2.98	$14.56
Cost of fuel, oil, coal, per 1,000 tons handled	1.16	6.92

OPERATING HOURLY AVERAGE COST

Fuel, oil, coal, water, etc.	$ .228	$ 1.18
Per car on and off floats	.038	.228
Per ton on and off floats	.0011	.0069
Cost per KW hour	.0109	
No. tons handled per hour	193	170
Rate BHP hours per gal. lub. oil	3820	
Lbs. fuel oil per KW hour generated	1.13	
Oil engine load factor	9.62%	

Cooling Troubles to Be Overcome

Apparently the time is not far off when engine cooling troubles will be greatly reduced and it will not be necessary to protect the radiator in cold weather nor to stop after a long uphill grind to let the engine cool down. This will be accomplished by constant temperature, or steam, cooling, as explained and demonstrated in an address at the annual meeting of the Society of Automotive Engineers by A. G. Herreshoff of the Rushmore Laboratory.

The purpose of engine cooling is to keep the cylinders as near as possible to the best operating temperature by the removal of excess heat due to combustion of the fuel.

Tests to determine the effect of different water-jacket temperatures on engine power, fuel consumption, and crankcase oil dilution indicate that a temperature of 212 degrees or slightly more is desirable.

The simplest natural means of accomplishing the purpose is by the use of boiling water, whose temperature remains constant at 212 degrees. The advantages of maintaining this jacket-water temperature under all conditions are that piston friction is reduced, there is better vaporization of the fuel, the dilution of oil in the crankcase by fuel and water is prevented or reduced, and rusting of the cylinder walls is prevented. The increase in engine efficiency resulting from an increase in cylinder wall temperature from 122 degrees with water cooling to 212 degrees with vapor or steam cooling should be 13 per cent for quarter engine load at low speed and 26 per cent at high speed, with resultant saving of 15 to 20 per cent in fuel consumption.

When a steam cooling system is used, it becomes a simple matter to heat the interior of the closed car body by passing the steam through a radiator in the body. Pressure of steam in the system also makes it possible to maintain a uniform temperature of the lubricating oil by conducting part of the condensed water through an oilpan jacket, thereby reducing the viscosity of the oil in cold weather, while the greater heat of the oil drives off any water and light fuel by which it is diluted, thus reducing friction and increasing the life of the engine.

National Defence

A Conference Held December 15, 1925

Under the Auspices of the

Engineers Club of Philadelphia

INTRODUCTORY REMARKS

By MAJ. CLAYTON W. PIKE,

President, Engineers Club of Philadelphia

THE subject of National Defense is one upon which many of the American people need education, and most of them need a continual reminder. Up to somewhere around 1917, the American people as a whole were wrapped in a complacent feeling that no foreign foe would ever dare to think of attacking this country and that, if they were foolish enough to think of it, they would be deterred by the oceans; and if, through sheer foolhardiness, some nation did attack us and land on our shores, that we would show them a few things about fighting and would send them back home with a very disagreeable remembrance of their first American tour.

The World War was a rude awakening. We found that the Constitution of the United States was not a complete guarantee of our eternal freedom; that if we wanted to preserve our liberty we would have to fight for it. And we did fight for it! This single club, The Engineers Club, had more than five hundred men in war service.

Those who have had the experience of war, and particularly those who have actually seen its horrors, are the people who most want to prevent it, or, if they cannot prevent it, want to lessen its horrors.

It is for that reason that this Club has thought it would be wise to hold this conference. We believe that a reasonable preparedness is an influence against war, or, if not an absolute influence which will prevent any conflagration, it will at least minimize the mistakes and the delays and will keep the destruction from being as great as it otherwise would be.

The Club hopes that this meeting will be helpful in spreading the doctrine of a reasonable preparedness. It has had the most earnest and helpful co-operation from the Army and Navy Departments, who have sent here their experts upon the various phases of preparation.

Perhaps the first phase that will occur to us is the question of manpower and—in fact, a corollary—of the organization of that manpower, for no matter how great the manpower, if it is not organized it becomes a mere mob.

Navy Mobilization Plans

By COMMANDER F. J. CLEARY, U. S. N.

ABOUT four years ago, at a Navy League dinner in the city of Washington, Assistant Secretary of the Navy, Theodore Roosevelt, defined pacifists as "people having brittle intellects."

Almost invariably, when officers of the Navy and Army discuss preparedness for war or plans for mobilization in case of war, these pacifists raise loud cries that the possession of armaments begets a desire to use them and that the officers of the Navy and Army constitute a military caste that desires war to provide glory and promotion and increased pay for its members. That the possession of armaments begets a desire to use them, is true only in the case of a nation possessing an aggressive military tradition and spirit.

The United States has never possessed such a tradition and spirit, and it will be most unfortunate for us and for the rest of the world if we ever develop them. With the exception of the Mexican War, which was in considerable part a war of conquest, every war in which we have engaged has been forced upon as as a reluctant people by developments which created an intolerable condition, and was waged in defense of those principles of justice, of liberty and of self-government for which millions of the best type of men and women of all countries and in all times have been willing to lay down their lives. It is unthinkable that the possession of an efficient, adequate navy would cause such a peace-loving nation as the United States to provoke a war, or even to take part in a war of aggression against another nation.

The officers of the Navy and the Army are as strongly opposed to war as are any other Americans; for it is upon us that the first brunt of war falls, and upon us that war places its most crushing burdens. War means to us of the Navy a hard and grinding task—it means exposure to death by scalding steam, by incandescent oil fires, by red hot jagged fragments of shell and armor, by the white hot flame of burning powder and by the frightful shattering effect of detonating high explosive. It means the loss of loyal comrades and shipmates of the long years that have passed, and it means the heavy responsibility for the thousands of lives that have been placed in our keeping and for the vital interests and welfare of 115,000,000 people and of their descendants.

As far as glory and promotion are concerned, let me cite one instance. The officer commanding our naval forces afloat during the war, numbering well over a thousand ships, and manned by about 300,000 officers and men, and upon whose shoulders rested the responsibilty of victory or defeat, held the temporary rank of Admiral during the war with a salary of $10,000 per year. After the war, when he left the fleet, he reverted to his permanent rank of Rear-Admiral, with a salary of $8,000 per year. He is now on the retired list with a salary of $6,000 per year. He is living in Philadelphia, yet I doubt whether there are twenty readers of this article who could tell me his name.

We urge preparedness and prepare plans for mobilization for the same reason that good citizens and thoughtful members of society in civil life take out fire insurance, establish an account in a savings bank or a surplus fund in their business, to safeguard themselves in time of trouble if it ever comes. We desire an adequate and efficient naval and military force so that, if war comes, we will be able to win for ourselves and for our fellow Americans, with the minimum expenditure of American lives and American treasure.

Naval Policy

Naval mobilization for war and the subsequent active naval campaign is based upon "Naval Policy," which is the system of principles, and the general terms of their application, governing the development, organization, maintenance, training and operation of a navy. It is based on, and is designed to support, national policies and national interests. It comprehends the questions of number, size, type and distribution of naval vessels and stations, the character and number of the personnel, and the character of peace and war operations. It should be clearly understood that the officers of the United States Navy have no hand in formulating the fundamental naval policy of the United States—nor the specific naval policy that governs for the time being.

The Fundamental Naval Policy of the United States is inherent in the Government and in the people, and will continue to be an inseparable part of its fabric as long as our Government endures. It may be thus defined—

"The Navy of the United States shall be maintained in sufficient strength to support its policies and its commerce, and to guard its continental and overseas possessions."

The present Specific Naval Policy of the United States is based on the Treaty for Limitation of Naval Armaments which was initiated by the late President Harding, negotiated by our civilian plenipotentiaries, Secretary of State Hughes, Mr. Elihu Root and Senators Lodge and Underwood, and approved by the United States Senate, and in general terms can be expressed as follows:

"The Treaty for the Limitation of Naval Armaments is the supreme law of the powers party to the treaty, governing their naval armaments as to capital ships and aircraft carriers. The spirit of the treaty indicates two elements of international import; first, a general desire to avoid competition in naval armaments and, second, a partial recognition of a ratio in naval strengths, as a means of avoiding competition. If any power signatory to the treaty undertook a program of expansion in unrestricted classes of naval vessels or in personnel not consistent with the treaty ratios of capital ships, a new competition in naval strengths would thereby be initiated.

"Until such times as other powers, by inequitable conduct in international relations as to United States interests or by their departure from the idea of a suspended competition in naval aramaments, indicate other procedure, the Navy of the United States will be governed in naval strengths by the spirit of the capital ship ratios.

The fundamental and specific naval policies of the United States having been determined and established by the civil Government, it then becomes the duty of the officers of the United States Navy to determine upon, and urge the adoption of, the detailed provisions necessary to make those policies effective.

Detailed Provisions

In general terms, those detailed provisions are:

"To create, maintain and operate a Navy second to none, and in conformity with the ratios for capital ships established by the Treaty for the Limitation of Naval Armaments.

"To make war efficiency the object of all training and to maintain that efficiency during the entire period of peace.

"To develop and to organize the Navy for operations in any part of either ocean.

"To make strength of the Navy for battle of primary importance.

"To make strength of the Navy for exercising ocean-wide economic pressure next in importance.

"To encourage and endeavor to lead in the development of the art and material of naval warfare.

"To cultivate friendly and sympathetic relations with the whole world by foreign cruises.

"To support in every possible way American interests, especially the expansion and development of American foreign commerce.

"To maintain a Marine Corps of such strength that it will be able to support the Navy adequately by furnishing detachments to vessels of the fleet in full commission, guards for shore stations, garrisons for outlying possessions, and by the maintenance in readiness of an expeditionary force.

"To co-operate fully and loyally with all departments of the Government."

Naval Aviation

The detailed provisions applying specifically to Naval Aviation are as follows:

"To complete rigid airships now under construction and to determine from their performance in service the desirability of further construction.

"To build non-rigid airships for development purposes only until their usefulness shall have been proved.

"To direct the principal air effort to that part of the air service that is to operate from ships of the fleet.

"To direct development of heavier-than-air craft principally toward spotting planes and toward torpedo, bombing and scouting planes that can operate from ships. To combine the three latter functions in one plane.

"To develop a combat plane for use afloat.

"To acquire combat planes only as necessary for training and for current requirements.

"To develop a scouting seaplane of long range for operations from a shore base or from a tender.

"To operate a spotting plane from each capital ship and from each modern cruiser.

"To determine by trial the practicability and desirability of operating additional planes from capital ships and from cruisers.

"To determine by trial the practicability and desirability of operating planes from destroyers and submarines.

"To give every possible encouragement to aviation in civil life with a view to advancing the art and to providing aviators available for war."

The plans for naval mobilization are based upon the imperative necessity of quickly gaining the command of the sea and holding it throughout the period of hostilities. If we gain the command of the sea, the safety of our continental and overseas possessions and the protection of our commerce are assured. If, on the other hand, the enemy gains the command of the sea, our overseas possessions will be lost, our commerce destroyed, and our continental coasts laid open to attack. The command of the sea can be gained and held only by adequate sea power, and the three most important elements that comprise sea power are—

First, a Navy adequate in number and types of ships, and in number of officers and men, and efficient by means of thorough training.

Second, properly equipped and defended bases for the use of the fleet in the areas where hostilities may be expected.

Third, a Merchant Marine adequate in number and types of ships, and in American personnel, to carry on the nation's trade and to supplement and to supply the fleet in time of war.

Lack of Essential Materials

Many people have the impression that we could carry on a successful war without sea-borne commerce. In fact, a high-ranking aviator, very much in the public eye, has stated that we are the most self-contained nation that has ever existed, and that we need no importation of raw materials in case of war. How far this impression and this statement depart from the actual facts, is shown by the accompanying list of raw materials, practically all of which are absolutely essential in time of war, and for which the United States depends largely or entirely on importation in merchant ships, and of which there are little or no reserve stocks carried in this country. The destruction of our sea-borne commerce would, therefore, deprive the manufacturing establishments in this country of the raw materials necessary to produce the finished products required for a successful naval and military campaign, and an enemy that had secured the command of the sea could destroy our sea-borne commerce without approaching nearer to the coasts of the United States than several hundred miles.

It is to be noted that the producing foreign country is not in all cases the country from which the goods are exported to the United States; thus a considerable portion of rubber, tea, wool, tin and silk are shipped to the United States from England. To illustrate the vital part the command of the sea exercises in modern wars, it will be of interest to state in general terms the influence it exercised in the Great War.

If Germany Had Controlled the Seas

Suppose Great Britain had remained neutral in the Great War, and the British Navy had never moved. What would have happened? The German and Austrian fleets, with a strength of three to one compared to the French and Russian fleets, would have quickly gained complete command of the sea. Germany would have supplemented her land attack by landing troops, or threatening to land troops, on both the Russian and French coast, in the rear of the Russian and French armies and, by such landing, or the threat of such landing, would have diverted large forces from the Russian and French fronts to protect their coasts. Germany would have shut off the French overseas trade, captured, destroyed or driven into port the French and Russian merchant marine, blockaded the French ports, thereby preventing the service in France of the French Foreign Legion and the French African troops and other

Material	Principal Use	Principal Foreign Source of Supply	Domestic Production	Estimated Required Importations First Year of the War
			Tons	Tons
Manganese	Manufacture of steel. Very high-grade manganese ore required in manufacture of high-grade steels, for ordnance matl. for aircraft matl., etc. (Large deposits of low-grade manganese ore in U. S. but deposits of high-grade manganese ore are very limited).	Brazil India	1918) 305,000 (1923) 32,000	1,200,000
Tungsten	Manufacture of high-speed tool steel.	China India	(1923) 250	12,000
Tin	Food containers, bearing metal, solder, bronzes	Straits Settlements, Bolivia	None	100,000
Nickel	Ordnance matl., engine forgings, shafting, monel metal.	Canada	Nominal	25,000
Graphite	Lubricants, crucibles	India Mexico Madagascar	5,000 to 15,000	35,000
Sodium Nitrate	Explosives, fertilizers.	Chile	Depends principally on possible production of fixation plants	1,500,000
Rubber	Automobile tires, mechanical-rubber goods, boots, shoes, insulating matls., gas masks, hospital supplies.	Straits Settlements, British and Dutch East Indies, India, Burma, Brazil	None	500,000
Cork	Life preservers, heat-insulating material.	Portugal, Spain	None	120,000
Iodine	Medicinal use	Chile	Practically none	700
Manlia, Sisal, Hemp, etc.	Cordage and twine	Philippines, Mexico	None	300,000
Jute	Burlap and gunny sacking	India	None	500,000
Wool (raw)	Clothing, blankets, etc.	Australia, Argentina, China	140,000	300,000
Silk	Clothing, powder bags, parachutes.	Japan, China	None	35,000
Shellac	Varnish, electrical apparatus.	India	None	20,000
Chinchona Bark and Quinine	Medicinal use	East Indies	None	7,000,000 oz.
Cocoa	Food	British West Africa, Brazil, Ecuador	None	300,000
Tea	Food	China, Japan, Ceylon	Nominal	80,000
Sugar	Food	Cuba, Hawaii, Philippines, Porto Rico	1,000,000	6,000,000
Coffee	Food	Brazil, Colombia, Venezuela	None	900,000

colonial troops and labor battalions, and France, with her chief industrial provinces in German occupation, would have been prevented by the German blockade from importing any food, raw materials or munitions, while Germany would have been free to draw on the resources of the world, and France, in spite of the splendid bravery and fighting spirit of her armies, would have been overwhelmed in less than six months.

But Britain, regarding her treaty guaranteeing the neutrality of Belgium as something more than a mere scrap of paper, entered the war, and the Grand fleet of Britain secured the command of the sea, and inflicted upon Germany and Austria what Germany and Austria had hoped to inflict on Russia and France. The loss of German colonies, the blockade of German and Austrian ports, the hunting down and destruction of the scattered German cruisers, first the neutrality and then the active military aid of Italy, the millions of men poured into France, the landing of troops at Gallipoli and Salonika, the protection of the Suez Canal, the Mesopotamian and Palestine campaigns, the food, coal and military supplies furnished Russia, France and Italy, the rescue of the remainder of the Belgian and Serbian Armies, the holding in line and final dethroning of the pro-German king of Greece, the landing of the United States troops in France, with their immense quantity of supplies, were all possible because of the command of the sea held by the British Grand fleet, aided and reinforced by the United States fleet after we entered the war.

A Remarkable Transportation Record

From the beginning of the war to the end of October, 1917, the Britsh Navy insured the safe transportation to the British and Allied Armies of 13,000,000 men, 2,000,000 horses, 25,000,000 tons of explosives and supplies, and 51,000,000 tons of coal, fuel oil and gasoline. The losses of men at sea out of the whole 13,000,000 transported were only 3,500, of which 2,700 were lost through the action of the enemy. Altogether, during this period, 130,000,000 tons of men and supplies were transported in British ships, protected by the British Navy. While I have not the exact figures at hand, I am conservative in stating that, from the beginning to the end of the war, there were transported under the protection of the British Navy and the United States Navy 20,000,000 men and 200,000,000 tons of men and military supplies. The Navy has been called our first line of defense, and rightly so, and in speaking of defense, we should keep in mind Admiral Farragut's maxim—"The best defense is a well directed and rapid fire from your own guns," and, as an extension of that maxim, the best means to defend our overseas possessions, our continental coasts and our sea-borne commerce, is to attack the enemy in the closest possible proximity to his shores.

Change of Our Frontiers

In the last war, our frontiers were thrust eastward more than 3,000 miles. In that war our frontiers were with Pershing's infantry patrols in "No man's land" and with his aviators over the German lines; our frontiers were in the North Sea, on the French Coast and in the Mediterranean with our destroyers, battleships and patrol ships, and on the decks of our armed merchantmen. Every troop transport, every ship carrying supplies and munitions to our troops abroad, and every ship carrying food, fuel, raw materials or finished products to the Allies, was guarded by the British Navy and the United States Navy, and that condition will prevail in any future war we wage, where it is necessary to transport an expeditionary force overseas. The more powerful that expeditionary force, the more vitally must it depend upon the Navy for its replacements in men and supplies.

It will be readily understood that the exact details of mobilization plans are confidential and cannot be publicly discussed, but the following general presentation of the Navy's plans for mobilization will show the care which has been taken by the Navy to provide for an emergency.

Plans for Naval Mobilization

Plans for Naval mobilization from a military standpoint differ materially from those for Army mobilization, on account of two reasons. First, that to gain the command of the sea the Navy must be prepared to take an active offensive almost immediately upon declaration of war and, through that offensive, enable the Army to complete its mobilization unmolested by an enemy. Second, while it is a comparatively quick and easy matter to mobilize man power, it is not possible to expand a Navy in material such as ships, in the same way, because of the fact that, even with the utmost rapidity of construction, it takes nine months to build a destroyer, eighteen months or two years to build a cruizer or a submarine and two years or more to build an aircraft carrier.

For these reasons, it is the policy of the United States to maintain a comparatively large Navy, as far as first line or fighting ships are concerned, and the Navy's plans for mobilization are directed primarily to putting the ships now out of commission in active commission ready for distant overseas service at the earliest practicable date. While additional aircraft carriers, cruisers and submarines and destroyer leaders would be immediately started upon the outbreak of hostilities, the only large expansion in ships upon mobilization would be by commissioning the naval ships now out of commission and by taking over the necessary merchant ships of American registry and either converting them to their new uses or utilizing them for purposes for which their present use makes them entirely suitable.

A Three-Period Mobilization

The general plan of mobilization of the naval ships is based on three periods:

A first period of time, ending at a known definite number of days after mobilization is ordered, in which the vessels assigned to the United States Fleet and to the Naval Transportation Service will be available at the concentration points in sufficient strength to enable the Commander-in-Chief to defend those concentration points against the attack of any enemy; a second period of time, ending at a known definite number of days after mobilization is ordered, during which additional ships would be added to the fleet at the concentration points so as to enable the Commander-in-Chief to move with the necessary forces to the intermediate bases selected; a third period of time, ending at a known definite number of days after mobilization is ordered, which will provide sufficient additional strength in ships to enable the Commander-in-Chief to move against the coasts of the enemy. For this purpose, four priority groups have been established:

The first group comprises vessels on service at points outside of the continental limits of the United

States, which are constantly kept in readiness for emergencies; the second group comprises the ships that would be available in the first period given above; the third group comprises the ships that would be available in the second period given above; the fourth group comprises the ships that would be available in the third period given above.

These four priority groups are farther sub-divided into the following sub-groups:

(A) Naval vessels in full commission;
(B) Naval vessels not in full commission;
(C) Vessels of other Government departments to be used by the Navy;
(D) Vessels of the Merchant Marine to be taken over and manned by the Navy;
(E) Vessels of the Merchant Marine to be chartered with their merchant crews.

Lists have been prepared and are kept up to date in accordance with the above priority and sub-groups. These lists show, for each naval vessel, listed the priority and sub-group, the mobilization point, and the number of days after mobilization is ordered when the ship will be ready to sail.

Mobilization of Merchant Ships

As far as the mobilization of merchant ships as additions to the fleet and as auxiliaries to the fleet is concerned, the Navy Department has worked out the following mobilization plan:

The maintenance in time of peace of a nucleus Naval Transportation Service, with provision for expansion in time of war into an organization which will support the United States fleet in its active operations and provide sea transportation for the United States Army.

The maintenance of a list, kept constantly corrected up to date, of merchant vessels of American registry, built or building, Coast Guard and Lighthouse Service vessels, best suited to be taken over for combatant purposes, for incorporation in the United States fleet and local defense forces upon mobilization. This list comprises ships for the following purposes:

Cruisers, second line;
Light cruisers, second line;
Mine layers, second line;
Aircraft carriers, second line;
Gun boats;
Patrol vessels;
Mine sweepers;
Sub-chasers.

The maintenance of a list, kept constantly corrected up to date, of merchant vessels of American registry, built or building, Coast Guard vessels, Army vessels, and Lighthouse Service vessels suitable to be taken over as auxiliaries, classified to meet war requirements in so far as can be foreseen. This list comprises vessels for the following purposes:

Destroyer tenders;
Submarine tenders;
Colliers;
Aircraft tenders;
Fleet repair ships;
Fleet store ships;
Fleet oilers;
Mine depot ships;
Fleet cargo ships;
Transports;
Hospital ships;
Fleet tugs;
Cable repair and cable-laying ships;
Distilling ships;
Salvage and wrecking ships.

The ships on these lists have been inspected and classified in accordance with their suitability into the following three major groups:

FLEET SHIPS—Capable of speed, radius of action and equipment to operate with the Fleet or with the Fleet train, and of serving the Fleet and its ships wherever they may be;

SERVICE SHIPS—Possessing the above characteristics in lesser degree, so that the ships are suitable for use in the transportation service only;

BASE SHIPS—Possessing the above characteristics in still lesser degree, so that the ships are suitable only for service between bases, depots and shore stations.

These lists show, also, the mobilization point to which these ships would proceed and the number of days, after mobilization was ordered, in which they would arrive at the mobilization point or the shipyard at which these ships would be converted, if any conversion is needed; the number of days after mobilization is ordered when the conversion would be completed; the mobilization point to which the ships would then move and the approximate date at which the ships would arrive at that mobilization point.

Conversion of Merchant Ships

Based on the above classifications and groups, the War Plans Division of the Office of Naval Operations furnishes the Material Section of the Office of Naval Operations with the types, number and names of ships and the purpose for which they are to be used and the shipyard where they will be converted, if any conversion is necessary.

The Material Section of the Office of Naval Operations transmits this information to the material bureaus concerned, Construction and Repair, Engineering, Ordnance and Aeronautics, and requests those bureaus to develop plans and prepare bills of material for the work necessary to convert these ships to the purposes desired.

Based on the survey already made, the bureaus make a further careful survey of the ships concerned, using the facilities of the Naval Districts for this purpose, and prepare the necessary plans and bills of material. Type plans, applicable in general to ships of the same approximate characteristics, are furnished in advance to the Naval Districts. Bills of material necessary are forwarded through the War Plans Division of Naval Operations to the Navy Section of the Munitions Board in the office of the Assistant Secretary of War, who, under the National Defense Act, is charged with the responsibility of procuring all material required for mobilization, and this Munitions Board, by means of its field forces, determines from what manufacturing establishments the necessary material can be obtained and the time in which it can be delivered, and those establishments are informed as to what material they will be called upon to furnish. This information is transmitted to the Navy Department, and to the various bureaus concerned. Then, when mobilization is ordered, detailed plans are sent to the shipyards concerned and orders for the material are placed by the Bureau of Supplies and Accounts with the manufacturers which have been previously designated.

The designation of Navy Yards or private shipyards, for the conversion of individual merchant ships, is based upon the peace-time location of those ships, and, whenever a ship is taken off one trade route and assigned to another, the designation of the shipyard where it is to be converted is changed, if necessary, and, as far as practicable, estimates of labor and material costs and the time necessary for the work of conversion are made, so that the Navy Department has information as to this feature.

Aircraft Mobilization

The mobilization plans for aviation are based on the mission of naval aircraft as follows:

1. As an arm of the Fleet;
2. For overseas scouting;
3. Against enemy establishments on shore, where the aircraft operations are conducted in co-operation with other types of naval forces, or alone when the aircraft mission is primarily naval;
4. To protect coastal sea communications by
   - (a) Reconnaissance and patrol of coastal sea areas,
   - (b) Convoy operations,
   - (c) Attacks on enemy submarines, aircraft or surface war vessels;
5. Alone or in co-operation with other arms of the Navy or with the Army against enemy vessels engaged in attacks on the coast.

To carry out this mission, the mobilization plans contemplate rushing the completion at the earliest practical dates the modern aircraft carriers "LEXINGTON" and "SARATOGA," placing priority orders for sufficient aircraft of various types which, added to those on hand, would supply the quantities needed to carry on the active operations, and, as previously described, a preliminary survey has already been made through the Munitions Board of the Office of the Assistant Secretary of War, so that it is known with what aircraft-building establishments these orders would be placed, and those establishments have been informed, so that this work could be taken in hand without conflicting with the Army's plans for procurement of aircraft.

Installation of catapults would be rushed to completion on all battleships, light cruisers and such other ships as will carry them, where these catapults have not already been installed, and in this connection, as already stated, a certain number of merchant ships will be converted to aircraft carriers and aircraft tenders. The exact number and the ships by name have already been determined. The number of fighting, bombing and torpedo planes to go on these ships has been definitely decided, and the necessary additional air stations would be started immediately.

Mobilization of Ordnance Material

The mobilization plans for ordnance material are based on the present organization, where there is a full allowance aboard ship of ammunition for all guns and torpedo tubes on all naval ships in full commission, and a full allowance at the Naval Ammunition Depots for all naval ships not in full commission. In addition, there is a ¾ fill of ammunition assembled and available at the Naval Ammunition Depots for immediate shipment to all these ships, and plans have been made so that this ¾ additional fill could be immediately loaded on cars or ships at the Ammunition Depots and started for the mobilization points. These points, of course, would depend upon the theatre of hostile operations. In further addition, there is maintained at the Naval Ammunition Depots a ¾ fill in bulk for all these ships, ready for loading and assembling as soon as the ¾ assembled fill now at the Ammunition Depots, available for immediate shipment, is started. In addition, the Bureau of Ordnance maintains a 25% reserve of all guns on naval ships in full commission and not in full commission, and an additional reserve which is based on the requirements for arming all merchant ships to be taken over by the Navy.

In addition to the above ammunition, which is ready for shipment or assembly, a carefully estimated list of the ammunition requirements of the naval service to provide for an extensive campaign has been prepared, the necessary surveys made, the manufacturing plants designated for furnishing raw material for this ammunition, and for manufacturing the completed product. This list comprises armor piercing and common shell of the large calibers, 12 in., 14 in. and 16 in., for common, flat nose, illuminating and anti-aircraft shell; for all other calibers, 8 in., 6 in., 5 in., 4 in., 3 in. and 37 m.m.; and the length of time, after the orders are placed when partial and complete deliveries of this ammunition will be made, is known, so that, without confusion, immediate orders for ammunition for an extensive campaign could be placed. Similar plans have been prepared in complete detail for torpedoes, smokeless powder, TNT, mines, and other ordnance material.

Mobilization of Personnel

As far as concerns the officer and enlisted personnel necessary to man all the ships, both naval and merchant, the following plan has been worked out. Naval ships not in full commission are divided into two groups as follows:

(1) Ships in commission with small nucleus crews;

(2) Ships out of commission with no crews.

In the case of the first group, the crews of those ships will be filled up to the necessary strength from the Fleet Reserve, which is composed of former enlisted men of from 16 to 20 years' service. In the case of the second group, the crews of those ships will be filled up to the necessary strength as follows: Ships in full commission, battleships, aircraft carriers, aircraft tenders, destroyers and submarines, having full crews, have included in their full crews nucleus crews of officers and men trained in advance and ready for instant transfer, and who are designated for a named ship of the same type, as far as practicable, now out of commission with no crew.

The Naval Districts concerned will furnish a "Fleet Reserve Unit" of trained men, and the crew will be finally filled up by partly trained men, designated "Reserve Crews," from the Naval Reserve of the District. As far as practicable, this plan provides that each Naval District furnish these reserve crews for only one type of vessel, so as to simplify the peace training necessary. Part training of these reserve crews is given in advance by cruises on ships of the type to which they will be ordered upon mobilization.

Each naval vessel to be mobilized will, therefore, have a small nucleus crew of highly trained men who have taken part in advance gunnery and torpedo practices and in full power steaming runs, and who are thoroughly familiar with everything concerned in the efficient operation of a naval vessel of the type on which they will serve.

To replace on the ships in full commission the nucleus crews referred to above, it is considered that sufficient officers and men can be obtained from the regular commissioned and enlisted strength of the Navy, by depleting to the amount necessary the officers now on duty at the Naval Academy, in the Navy Department, and in the Naval Districts and, as far as the enlisted men are concerned, by taking them:

(a) From training stations, by reducing the course at those training stations to a minimum of three weeks;

(b) From trade schools;

(c) By recalling all men on leave; and

(d) By stopping all men in transit for transfer from one ship to another.

The Fleet Reserve Units will also be utilized to furnish nucleus crews for merchant ships, as far as possible, from the same district as the mobilization point for the vessels concerned.

The recruiting district boundaries will be modified somewhat from their present boundaries to correspond with the boundaries of the Naval Districts. The senior recruiting officer in each Naval District will confer with the Commandant to assist in completing plans for the mobilization of the old personnel and the procurement of new personnel to the extent of 15,000 officers and 105,000 men within thirty days after mobilization is ordered, as an initial step. This initial increase in strength of 15,000 officers and 105,000 men is based upon the present maximum capacity for housing and training now available in the districts. These officers and men will be used largely to man merchant vessels taken over by the Navy and in lesser numbers to add to the crews of destroyers, aircraft carriers and aircraft tenders, submarines and submarine tenders.

The commandants of districts are in general charge of the above mobilization of personnel, and each District has assigned to it a quota of officers of each specialty, as well as a quota of enlisted men suitable for each specialty, to be recruited in that District.

Officer candidates recruited will be obtained in about the following proportion:

Aviation	10%
Engineering	25%
Communication (radio, sound, etc.)	10%
Deck	55%

The new recruits for enlisted men to be procured will consist of four classes:

(1) Trained ex-Navy men;

(2) Men skilled in trades corresponding to a Navy specialty, which will enable these men to be utilized without naval training, such as machinists, boilermakers, coppersmiths, blacksmiths, moulders, instrument men, Diesel engine operators and repair men, gasoline engine operators and repair men, carpenters, yeomen (storekeepers, accountants, stenographers and typists), and radio operators;

(3) Men requiring naval training;

(4) Men actually serving in the Army transport service or in merchant vessels and who are qualified for continued service abroad.

As these new officers and new enlisted men are withdrawn from the shore stations and training schools and sent to ships, additional new officers and new enlisted men will be recruited in accordance with the increasing demands for personnel. Toward the end of the last war, the personnel of the Navy numbered approximately 60,000 officers and 500,000 enlisted men, and an extensive future campaign would probably demand an equal number of personnel.

(Record of Meeting will be continued in April issue)

Quartz-Gallium Thermometers*

Laboratory Curiosities of Yesterday Become Commercial Products of Today

A NUMBER of metals now in common use were little known in practical work even a half-century ago, among them aluminum, magnesium, molybdenum, manganese, palladium, iridium, osmium, vanadium and tungsten. Cobalt, nickel, antimony, bismuth, tantalum and certain other metals were known only in a limited way. Silicon, so abundant in the rocks of the earth, was practically unknown until produced at Niagara by the electric furnace twenty-five or thirty years ago. Other little known elements are coming into use gradually, on account of special properties which have possibilities. New uses are being found for even rare elements, either as the pure metals or in alloys oftentimes possessing unexpected and remarkable properties.

Although clear fused quartz has been known in small quantities for at least thirty years, production of high-grade clear fused quartz in large quantities was an achievement of the Thomson Research Laboratory of the General Electric Company at Lynn, Massachusetts, only a few years ago. It is remarkably transparent and but little affected by temperatures at which most metals melt.

Gallium was discovered by a French scientist, Lecoq de Boisbaudran, in 1875, and derived its name from Gallia, the Latin for France. But little further work was done with the element. The existence of such a chemical element had been predicted several years before. Its characteristic lines were observed by the discoverer while examining the spectrum of a piece of zinc blende. Known for 50 years as a rare metal, it never had any commercial use until Sylvester Boyer, in the Thomson Research Laboratory, recently produced the gallium thermometer for the measurement of higher temperatures than can be measured with mercury-and-glass thermometers.

Gallium, when liquid, is similar to mercury in appearance, but is less than half as heavy. It melts at about 86 degrees Fahrenheit but often may be cooled to more than 8 degrees below zero, before becoming solid. It does not boil (give off vapor) under 2700 degrees Fahrenheit, its boiling point being estimated at between 1500 and 2000 degrees Centigrade, equivalent to about 2700 to 3600 degrees Fahrenheit. Because of certain impurities the liquid metal formerly wetted glass and quartz, and therefore was unsuitable for thermometers. It was first made suitable for thermometer use by the recent work of Boyer. Quantities of the metal can now be prepared for whatever uses may be developed. By utilizing the properties just mentioned of these two materials a convenient new high-temperature thermometer became practicable. The quartz-gallium thermometer differs little in appearance from the ordinary mercury thermometer. It could not be made sooner because the two substances, although known, were commercially unavailable.

In the United States a source of gallium was discovered ten years ago in the "leady residues" left after the distillation of zinc from certain ores. Residues from such ores in Missouri and Oklahoma contain considerable gallium but, since there were no commercial uses for gallium, these residues were sold only for the lead in them.

Science is conquering slowly or rapidly, as you prefer to look at it. Compared with ancient times, its conquests now proceed at express speed. From the standpoint of desirable progress, the speed is slower than we would like to have it. From time to time the missing chemical elements in the predicted list are being found. Only two or three of the elements which form the whole material universe remain undiscovered on the earth. Most of the 92 elements have been put to use by Man.

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*Extracts from Engineering Foundation Research Narrative No. 112 Based on information furnished by Sylvester Boyer, Thomson Research Laboratory, General Electric Company, Lynn, Massachusetts .

See also Research Narratives Nos. 5, 14, 16, 35, 40, 45, 70, 73, 87, 91, 99, 106. See NEW BOOKS, sec page II this issue.

CONSERVATION OF FUELS FOR MOTOR VEHICLES

Discussed at a Joint Meeting of

The Engineers Club of Philadelphia
The American Society of Mechanical Engineers (Philadelphia Section)
Society of Automotive Engineers (Philadelphia Section)

Held at The Engineers Club, January 19, 1926

The Gasoline Situation*

By H. H. HILL

Chief Petroleum Engineer, Bureau of Mines, Department of Commerce

THE United States has often been referred to as a nation on wheels. It might properly be called a nation on rubber tires, or even better, a nation that rides behind gasoline engines. There are now approximately 20,000,000 automobiles and trucks in this country, which is somewhat more than 80% of those in use in the entire world and is equivalent to 1 car for each 6 people. When we consider that the total registration includes motor busses and trucks we find that by a little crowding it would be possible to load the entire population of the United States into the motor vehicles now available.

The remarkable growth of the automotive industry has been attributed to a number of factors such as the roving spirit of the American people and their desire to attain high standards of living; the inventive genius of our engineers and metallurgists, resulting in the development and application of alloy steels; improvements in automotive equipment, such as the self-starter; more general use of the closed car; partial payment plan for purchasing automobiles, etc., but probably no single factor has been so important as a plentiful supply of a relatively cheap fuel and its availability even in the most remote sections of the country. We not only have more than 80% of the automobiles of the world, but we also produce more than 70% of the world's production of crude oil (70.5% in 1924) and consume practically the same percentage of the total.

History of Crude Oil Production

Although the United States has been producing crude oil since 1859 and up to January 1 of this year has produced approximately 8,664,000,000 barrels, it is interesting to note that during the past ten years the production has amounted to 58% of the total and that during the past five years we have produced 37% of all the oil that has been taken from the ground since the first well was drilled. Also, the average monthly production for the year 1925 was practically the same as the entire production for the year 1900. These figures clearly illustrate the remarkable growth of the petroleum industry during the past few years. Production figures for the 10 year period 1916 to 1925 inclusive are shown in Column 1 of Table 1. It will be noted that during this brief period the production has increased from 300,767,000 barrels in 1916 to an estimated figure of 758,000,000 barrels in 1925, a gain of 152%. The production for 1925 averages somewhat more than 2,000,000 barrels a day, reaching a peak of 2,346,900 barrels daily during the last week of May and declining to 1,972,550 barrels daily at the end of the year.

History of Gasoline Production

The production of gasoline has increased even more rapidly than the production of crude oil. Formerly considered as a waste product from the refineries, gasoline did not become an important product from crude oil until the development of the automobile provided a market for a highly volatile fuel. In 1904, when the automobile industry was just getting well under way the production of gasoline was 290,640,000 gallons, while in 1925, with 20,000,000 cars to supply, the production of gasoline amounted to approximately 10,860,000,000 gallons or 37 times the production of 1904. The production of gasoline like the production of crude oil, has increased very rapidly during the past few years. Column 3 of Table 1 shows that for the ten-year period—1916 to 1925 inclusive—the gasoline production of the United States increased from approximately 2,059,000,000 gallons to 10,860,000,000 gallons, an increase of 427%.

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*Paper read before the Engineers Club, Philadelphia, Pa., January 19, 1926, and published by permission of the Director, Bureau of Mines.

TABLE 1

Data on Production of Crude Oil, Refinery Production of Gasoline, Registration of **Cars** and Trucks and Gasoline Prices for the 10 Year Period 1916 to 1925, Inclusive

Year	(a) Production of crude oil. Bbls.—42 gal.	(d) Crude oil run to stills. Bbls.—42 gal.	(d) Production of gasoline. Gallons	Yield of gasoline. Per cent	(d) Indicated domestic demand for gasoline. Gallons	(b) Registration of car and trucks	Gallons of gasoline per car based on mean number of cars registered at beginning and end of year	(c) Average tank wagon (wholesale price of gasoline New York City) cts. per gallon
1916	300,767,000	246,992,015	2,058,880,596	19.8	....	3,512,996	...	23.0
1917	335,316,000	315,131,681	2,850,546,423	21.6	2,363,230,401	4,983,340	556	23.8
1918	355,928,000	326,024,630	3,570,312,963	26.1	3,129,266,347	6,146,617	562	24.2
1919	378,367,000	361,520,153	3,957,857,097	26.1	3,434,812,486	7,565,446	501	24.5
1920	442,929,000	433,915,029	4,882,546,699	26.8	4,250,696,163	9,231,941	506	29.3
1921	472,183,000	433,362,657	5,153,549,318	27.7	4,516,027,256	10,463,295	459	26.1
1922	557,531,000	500,705,616	6,202,234,613	29.5	5,372,085,042	12,238,375	473	25.1
1923	732,407,000	581,237,816	7,555,945,143	30.9	6,685,035,280	15,092,177	489	20.7
1924	713,940.000	643,719,349	8,959,680,220	33.1	7,783,498,908	17,591,981	476	18.0
1925	758,000,000*	740,000,000*	10,860,000,000*	34.9*	9,310,000,000*	20,100,000*	494*	19.1

*Estimated.

(a) Data from U. S. Geological Survey and U. S. Bureau of Mines.
(b) Data from U. S. Bureau of Public Roads.
(c) Data from U. S. Department of Labor.
(d) Data from reports on Refinery Operations—U. S. Bureau of Mines.

History of Automobile Registration

As remarkable as has been the increase in the production of crude oil and of gasoline, the growth of the automobile industry has been even more spectacular. Starting in the late nineties with a total production of only 3,723 cars in the year 1899, the production has increased by leaps and bounds, exceeding 4,000,000 cars and trucks in the year 1925. The registration of cars and trucks has shown a correspondingly rapid increase, particularly during the past few years. Column 6 of Table 1 shows that the registration of cars and trucks in this country has increased from 3,512,996 in 1916 to an estimated total of 20, 100,000 in 1925, an increase of 472%.

Comparison of Increases of Crude Oil Production, Gasoline Production and Registration of Cars and Trucks

It has been shown that during the ten-year period from 1916 to 1925, inclusive, which represents the most rapid growth in the number of cars and trucks in use, the production of crude oil increased 152%, the production of gasoline increased 427%, and the number of cars and trucks registered increased 472%. In other words there was 2½ times as much crude oil produced in 1925 as in 1916, 5.3 times as much gasoline produced and 5.7 times as many cars and trucks registered. Although the increase in cars registered has been slightly higher than the increase in the production of gasoline, the amount of gasoline available to operate the cars has been adequate. Despite the fact that the number of barrels of crude oil per car registered decreased from approximately 100 barrels per car in 1916 to about 40 barrels in 1925, the production of gasoline has been sufficient to take care of the domestic demand and allow a reasonable amount for export. Column 7 of Table 1 shows the number of gallons of gasoline per car based on the mean number of cars registered at the beginning and end of the year. It will be noted that the figure decreased from 562 gallons per car in 1918 to 459 in 1921 and has since increased to an estimated figure of 494 for 1925. The increase in the average gasoline consumption per car is doubtless due to the increasing percentage of trucks and motor buses. No figures are available on the percentage of gasoline that is used for automobiles as compared to the amount used for other purposes, but it is believed that the percentage has been fairly uniform from year to year and for that reason the figures on gasoline demand per car probably reflect the changes in actual consumption.

Meeting the Demand for Gasoline

Although the extremely rapid growth of the automobile industry has placed a real responsibility on the oil industry to provide sufficient fuel to keep the cars in operation, the industry has been equal to the task and has made it possible for the motorist to secure a satisfactory fuel at all times. In order to meet this demand, the oil industry has had to extend itself, as thousands of wells have been drilled, a large number of which have not been profitable and constant improvements have been made in refinery practice in order to get more gasoline out of the crude. A number of factors have contributed to increased production of crude oil, among which the following may be mentioned:

(a) Improved methods for locating favorable structures.

(b) Improvements in drilling methods.
(c) Improvements in drilling equipment.
(d) Improved production methods.

During the past two years, scientific instruments such as the seismograph and torsion balance have been used with considerable success in locating structures that are favorable for the accumulation of oil, particularly in the Gulf Coast district where oil is usually found associated with salt domes. The diamond drill has also been used successfully in Oklahoma for locating structures that are not evident on surface indications. The discovery of at least two fields in Oklahoma is attributed to information that was obtained by core drilling with the diamond drill.

Although a number of important developments have been made in drilling methods, particularly in those employed in rotary drilling, probably the most important has been the development and use of the rotary core barrel. By using the core barrel it has been possible not only to locate oil sands that would be passed up in the ordinary method of rotary drilling, but also to determine proper points for landing casing in order to prevent the entrance of water into the well. A more general use of mud and cement has doubtless resulted in the recovery of thousands of barrels of oil that would otherwise have been lost, due to the entrance of water into the wells and the migration of oil and gas into barren sands above.

Improvements in drilling equipment have made it possible to obtain oil from sands that only a few years ago were considered beyond the reach of the drill. Several of the most prolific fields in California are producing oil from depths in excess of 4,000 feet and there are a number of deep wells in Oklahoma, Colorado and Texas. A number of wells in California are producing from depths of 5,000 to 6,000 feet and the deepest producing oil well in the world, which reached a total depth of 7,591 feet and is producing from a sand at 7,300 feet, is in the Athens Field in California.

In addition to improvements in locating structures and in drilling the wells, there has been a constant effort on the part of the oil producer to obtain more oil from the sands and to save the oil after it has reached the surface. Improvements have been made in pumping equipment so that it is now possible to lift oil from the deep wells. Additional amounts of oil are now being recovered from oil-water emulsions and in some sections of the country operating methods are being changed in order to make better use of the gas that is produced with the oil. Evaporation losses on the lease are being appreciably reduced by the installation of gas tight tanks and a large percentage of the gas that is produced with the oil is being run through absorption or compression plants in order to recover the gasoline that it contains.

Improvements in Refinery Practice

The part played by the oil producer, in supplying fuel for the motor cars in use, has been very important but, as previously noted, he has increased his production to only 2½ times that of 1916, while the refiner has increased the production of gasoline to more than 5 times that of 1916. The manufacturer of natural gas gasoline also has had an important part in increasing gasoline production as he has contributed a product that has materially helped the refiner in increasing the yield of gasoline from the crude. As shown in Column 4 of Table 1 the refinery yield of gasoline has increased from 19.8% in 1916 to 34.9% in 1925. This has been due to a number of factors, chief of which are the following:

(a) Improvements in fractionating equipment.
(b) More general use of cracking processes.
(c) Use of natural gas gasoline.

Other factors that doubtless have contributed to an increased yield of gasoline are: Reduction of evaporation losses on the lease and at the refinery, as the material lost was largely gasoline; a slight lowering of the volatility of gasoline marketed; recovery of gasoline from still vapors and a more general use of improved refinery equipment such as continuous treaters, etc. These improvements, although important, would account for only a small percentage increase in the gasoline yield.

Importance of Improvements in Fractionating Equipment

No figures are available to show the importance of improved fractionating equipment in increasing the yield of gasoline, but it is believed that such equipment has had a decided effect. Bubble towers now in use in some of the refineries have resulted in increased yields of gasoline amounting to as much as 6 to 8% by straight distillation of crude oil. Equipment of this kind has not as yet been generally adopted by the refiners and for that reason it will be of more importance in the future than at present.

Importance of Cracking

According to the best information available, about 26% of the gasoline output of the refineries for 1925 was produced from heavier oils by cracking. This represents a production of approximately 2,824,000,000 gallons of gasoline by the use of cracking processes as compared to 400,000,000 gallons in 1918 and 1,000,000,000 gallons for the 5-year period preceding 1918. In other words almost 7 times as much gasoline was made by cracking in 1925 as in 1918, and almost 3 times as much as for the 5-year period preceding 1918.

This amount of cracked gasoline has been extremely important in providing fuel for the motor vehicles now in use as it has meant an increase in the amount of gasoline available without a corresponding increase in the production of crude oil. On the basis of the estimated yield of gasoline for 1925 by straight distillation (23.4%), it would have required approximately 287,000,000 barrels additional of crude oil to furnish the gasoline made by cracking processes.

Importance of Natural Gas Gasoline

Approximately 7% of the gasoline output of the refineries for 1925 was due to natural gas gasoline that was brought to the refineries and either run through the stills or blended with gasoline to produce a finished motor fuel. This amounted to about 760,000,000 gallons and represents approximately 60% of the total production of natural gas gasoline for that year. The amount of natural gas gasoline that was used at the refineries in 1925 was equivalent to the gasoline yield by straight distillation (23.4%) from approximately 77,000,000 barrels of crude oil and the total natural gas gasoline production for that year was equivalent in amount to the gasoline that would be obtained from 129,000,000 barrels of crude oil by straight distillation. The amount of natural gas gasoline produced is even more important than is indicated by the above figures for, due to its extremely high volatility, it has rendered available as motor fuel large quantities of distillates that would be unsatisfactory as motor fuel if used alone, due to the lack of low boiling material.

If the gasoline production for 1925 had been obtained entirely by straight distillation of crude oil the gasoline yield would have been 23.4% (67% of 34.9%), and instead of running 740,000,000 barrels of crude oil to the stills it would have been necessary to use 740,000,000 plus 287,000,000 plus 129,000,000 or 1,156,000,000 barrels, which amount exceeds the world's production for 1924. If the production of gasoline had been limited to the domestic demand and the entire amount had been made by straight distillation, it would have required approximatedy 950,000,000 barrels of crude oil which is almost 200,000,000 barrels (about 520,000 barrels daily) in excess of the production of the United States for the year 1925.

Use of Substitute Fuels

Blended fuels consisting of benzol and gasoline, or benzol and naptha, are used in certain sections of the country and have helped to some extent in meeting the demand for motor fuel. The amount of such fuels is very small when compared to the amount of gasoline used, as the production of benzol amounts to about 6,500,000 gallons monthly as compared to a production of gasoline of approximately 30,000,000 gallons daily. Blended fuels containing alcohol were sold in a number of Eastern cities shortly after the war, but have apparently been withdrawn from the market.

Possibilities for the Future

The question is often asked, can the oil industry continue to furnish the vast quantities of gasoline that will be needed for the cars and trucks that are now in use and the increased number that will doubtless be in use from year to year? No attempt will be made to answer that question. Attention is called, however, to the following factors that will doubtless be important in contributing to a supply of fuel for our motor vehicles:

(a) Additional improvements in methods of locating oil deposits.

(b) Improvements in drilling methods that will result in even deeper drilling.

(c) Improvements in pumping equipment that will make it possible to lift oil from greater depths than at present.

(d) More efficient use of gas for recovering oil from the sands.

(e) More extended application of artificial methods of recovery.

(f) Increased use of cracking processes.

(g) Increased efficiency in distillation equipment.

(h) Importation of foreign oils.

(i) Development of substitute fuels.

(j) Increased efficiency in utilization.

Particular attention is called to items a, e, f and j. Although the other factors mentioned will doubtless be very important, these four appear to be outstanding at the present time. It will be necessary to discover new fields, therefore any improvements in methods for locating favorable structures will be extremely important as some structures that contain oil have doubtless been overlooked due to limitations in the methods that have been followed in the past. Since a large percentage of the production of this country has been coming from new fields a decided drop in the amount of flush production would result in temporary shortages at least.

Artificial methods of recovery such as the use of compressed air or gas, water flooding, or some method not yet in use, will doubtless have a very important bearing on the future production of crude oil and likewise on the supply of motor fuel. Estimates differ as to the percentage of oil that is left in the sand after making use of our present methods of flowing and pumping, but the figures often used are from 60% to 80% of the total amount of oil originally contained in the sand. Since the production to date has been in excess of 8,000,000,000 barrels, the amount remaining in the sands would therefore be between 12,000,000,000 and 32,000,000,000 barrels. The recovery of at least a part of this oil is probably the most improtant problem that confronts the oil industry. The introduction of compressed air and gas has been successful in limited areas and at present there is an immense amount of activity in the district around Bartlesville and Nowata, Oklahoma. Water flooding as a means of recovering additional quantities of oil from the sand has been successfully employed in the Bradford Field in Pennsylvania for several years. Since there are now more than 300,000 producing oil wells in this country in addition to several thousand that formerly produced oil but have been abandoned, it can be realized that an appreciable increase in the production per well would add large quantities of oil to our daily output.

There is probably no one factor that is more important from the standpoint of a future supply of motor fuel than a more extended use of the cracking process in the refineries of the country. As previously stated, approximately 26% of the refinery output of gasoline in 1925 was made by cracking heavier oils. This figure could be materially increased, as processes are now in use that will convert almost all grades of heavy oil into gasoline. The production of gas oil and fuel oil for the year 1925 was approximately 15,300,000,000 gallons, or about 49% of the crude oil charged to the stills. Although part of this material is used for gas making purposes and a certain percentage is burned as fuel for purposes where coal could not be satisfactorily used, a large percentage is used in direct competition with coal and, if necessary, could be replaced by that more plentiful fuel. This gas oil and fuel could be used for the production of gasoline by cracking and, if used for that purpose, it would be possible to double the production of gasoline by the cracking process without using all the material that would be available. It would doubtless be more expensive to manufacture gasoline from this material than from the distillate oils that are now generally used but, if needed for motor fuel, it could be made available for that purpose.

Efficiency in Utilization

Automotive engineers have frequently stated that it is possible to double the efficiency of the present type of automobile engine which would result in doubling the miles per gallon of gasoline. If this can be accomplished, its importance on the future consumption of gasoline can be readily appreciated, as 40,000,000 cars and trucks could be operated on the amount of gasoline that is now being consumed, or we could operate the present number of cars and trucks on one-half the gasoline that is now consumed as motor fuel. Doubtless a new fuel that will stand high compressions will be required in order to obtain satisfactory results, but it is understood that a number of refiners are now making an extended effort to develop such a product and it is very possible that a suitable fuel will be available by the time a new type of engine is in general use.

To summarize:

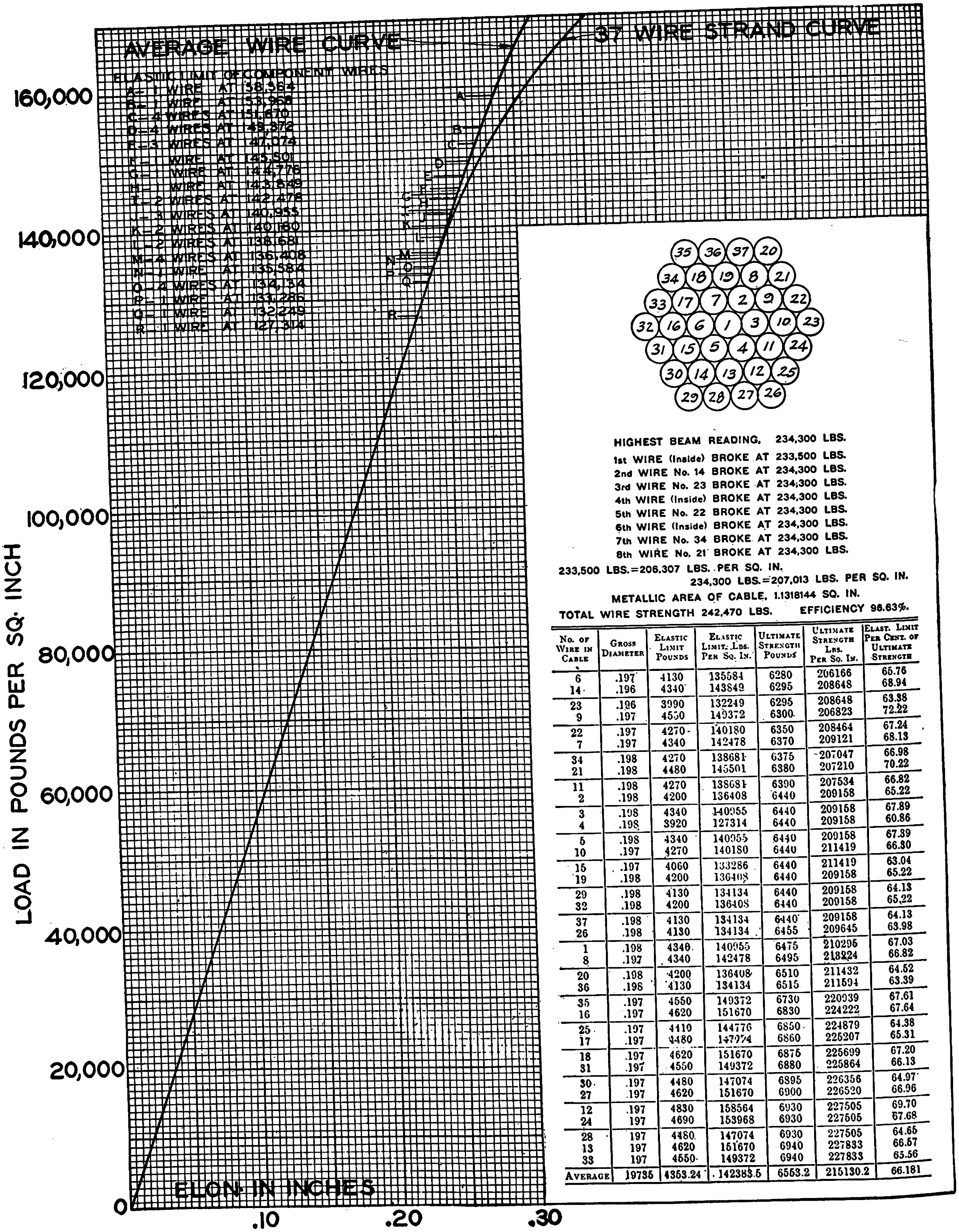
The oil industry has been able to meet the gasoline demand of the past by developing new fields, by improvements in drilling and production practices, by recovering increasing amounts of gasoline from natural gas and by a more general use of the cracking process for manufacturing gasoline from heavier oils.

If the producer of crude oil will appreciably increase the percentage recovery of oil from the sand, if the refiner will double the production of gasoline made by the cracking process, and if the automobile manufacturer will market cars that will travel twice the distance of the present cars on the same amount of motor fuel, we will not need to discover new fields as often as in the past nor to maintain the same rate of increase in the production of crude oil, in order to meet the gasoline demand of the future.

(Record of Meeting will be continued in April issue)

HEAVY TIMBER MILL CONSTRUCTION

Architectural designers and draftsmen will greatly appreciate a recent important contribution to technical information issued by the National Lumber Manufacturers' Association, Washington, D. C., under the title, "Details of Heavy Timber Mill Construction." This bulletin illustrates good practice in heavy timber mill construction detailing and furnishes a distinct service not elsewhere available in compact and simple form. It will be mailed free upon request. Occasional searches, which designers and draftsmen make for such details are likely to fail to reveal the kind of material desired with the result that the features which are actually essential in this type of construction are often omitted.



HIGHEST BEAM READING, 234,300 LBS.

1st WIRE (Inside) BROKE AT 233,500 LBS.
2nd WIRE No. 14 BROKE AT 234,300 LBS.
3rd WIRE No. 23 BROKE AT 234,300 LBS.
4th WIRE (Inside) BROKE AT 234,300 LBS.
5th WIRE No. 22 BROKE AT 234,300 LBS.
6th WIRE (Inside) BROKE AT 234,300 LBS.
7th WIRE No. 34 BROKE AT 234,300 LBS.
8th WIRE No. 21 BROKE AT 234,300 LBS.

233,500 LBS.=206,307 LBS. PER SQ. IN.
234,300 LBS.=207,013 LBS. PER SQ. IN.

METALLIC AREA OF CABLE, 1.1318144 SQ. IN.

TOTAL WIRE STRENGTH 242,470 LBS. EFFICIENCY 96.63%.

No. of Wire in Cable	Gross Diameter	Elastic Limit Pounds	Elastic Limit, Lbs. Per Sq. In.	Ultimate Strength Pounds	Ultimate Strength Lbs. Per Sq. In.	Elast. Limit Per Cent. of Ultimate Strength
6	.197	4130	135584	6280	206166	65.76
14	.196	4340	143849	6295	208648	68.94
23	.196	3990	132249	6295	208648	63.38
9	.197	4550	149372	6300	206823	72.22
22	.197	4270	140180	6350	208464	67.24
7	.197	4340	142478	6370	209121	68.13
34	.198	4270	138681	6375	207047	66.98
21	.198	4480	145501	6380	207210	70.22
11	.198	4270	138681	6390	207534	66.82
2	.198	4200	136408	6440	209158	65.22
3	.198	4340	140955	6440	209158	67.89
4	.198	3920	127314	6440	209158	60.86
5	.198	4340	140955	6440	209158	67.39
10	.197	4270	140180	6440	211419	66.30
15	.197	4060	133286	6440	211419	63.04
19	.198	4200	136408	6440	209158	65.22
29	.198	4130	134134	6440	209158	64.13
32	.198	4200	136408	6440	209158	65.22
37	.198	4130	134134	6440	209158	64.13
26	.198	4130	134134	6455	209645	63.98
1	.198	4340	140955	6475	210296	67.03
8	.197	4340	142478	6495	218224	66.82
20	.198	4200	136408	6510	211432	64.52
36	.198	4130	134134	6515	211594	63.39
35	.197	4550	149372	6730	220939	67.61
16	.197	4620	151670	6830	224222	67.64
25	.197	4410	144776	6850	224879	64.38
17	.197	4480	147074	6860	225207	65.31
18	.197	4620	151670	6875	225699	67.20
31	.197	4550	149372	6880	225864	66.13
30	.197	4480	147074	6895	226356	64.97
27	.197	4620	151670	6900	226520	66.96
12	.197	4830	158564	6930	227505	69.70
24	197	4690	153968	6930	227505	67.68
28	197	4480	147074	6930	227505	64.65
13	197	4620	151670	6940	227833	66.57
33	197	4550	149372	6940	227833	65.56
Average	19735	4353.24	142383.5	6553.2	215130.2	66.181

STRESS-STRAIN DIAGRAM FOR 37-WIRE STRAND AND INDIVIDUAL BRIDGE WIRES

Construction of Parallel Wire Cables for Suspension Bridges*

John A. Roebling's Sons Company, Trenton, New Jersey, have issued a booklet—9x12 in., 23 pages of text plus 60 half-tones and 8 diagrams.

It contains interesting historical data and useful statistical information about suspension bridge construction and the properties of the bridge cable wire and suspender rope and is issued to advertise Roebling cable wire. It consists of three parts,—first, a historical and descriptive account of wire cable bridges; second, a discussion of the properties of cable wire and suspender rope, as shown by certain special tests, and of the methods of wire spinning; and third, a pictorial study of the construction of the Bear Mountain-Hudson River Bridge.

The first portion of the text presents the principal dimensions of 14 Roebling bridges built between 1844 and 1924. Then follows a description of the Bear Mountain-Hudson River Bridge. It was on the cables of this structure that flat wire bands for serving the individual strands were first used. This practice obviates the necessity of compacting the central core and successive outer layers and permits the entire cable to be compacted at one operation from its hexagonal formation as spun, the flat bands being left in the cable.

The data presented in the description of special tests are of importance as relating to cable design. The tests indicated: (1) That because of slippage between the wires, parallel wire cables are not subject to excessive secondary stresses from bending; (2) That side pressure on the wire, such as is produced at the cable saddles, up to 5,500 pounds per lineal inch, has little effect on the elastic limit but that greater pressure lowers the elastic limit to an appreciable degree; (3) That the modulus of elasticity of a strand of wires is equal to the average of the wires composing the strand; (4) That bending wire around a sheave of 9-inch radius does not reduce its ultimate strength; (5) That the tensile strength of the wire is uniform throughout its section; (6) That satisfactory coefficient of friction between cable bands and the wire can be secured by special machining; and, (7) That the elastic limit of suspender rope is approximately 60 per cent of its ultimate strength.

This booklet is generally well planned and will be of value to bridge engineers. The readers will not fail to note the absence of any reference to the Delaware River Bridge. As is well known, many of the special tests referred to were made at the instigation of and with the co-operation of the Delaware River Bridge Joint Commission. The omission is obviously attributable to the desire to limit the book to Roebling products.

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*Review by Charles Carswell, Ass't Engineer, Delaware River Bridge Joint Commission, Philadelphia, Pa.

Paradoxical Cure for Automobile Oiling Ills

To cure the engine troubles due to dilution of the lubricating oil in the crankcase by diluting the oil before putting it into the engine was the startling proposal made at the annual meeting of the Society of Automotive Engineers in Detroit the last week in January by Robert E. Wilson and Robert E. Wilkin, of the Standard Oil Company of Indiana.

The suggested remedy for lubrication troubles, such as difficult starting in cold weather when the oil is very stiff and does not flow to the cylinder walls and bearings, followed by inadequate lubrication with the oil too thin in hot weather operation or when the engine is running at full load in low car speed, is to dilute a fairly heavy oil with from 10 to 12 per cent of a petroleum distillate that is practically identical with the heavy ends of the gasoline that gets into the present oils in the crankcase.

By this means it is possible to produce an oil that is thin enough to give easy starting and good cold weather lubrication and yet is so near to the average constant percentage of dilution in cars in use on the road that in general the pre-diluted oil will maintain its viscosity throughout its entire period of service.

This paradoxical method of solving some of the lubrication ills due to oil dilution in the engine was heartily approved by a number of automotive experts present at the meeting, who corroborated many of the statements made and asserted their belief that the proposed remedy was entirely feasible and would reduce the oil consumption as well. The use of air cleaners, oil separators or purifiers, and water eliminating devices to keep the oil in the engine clean would be just as desirable with the pre-diluted oil as with the present oils, it was said, but with such devices in use on cars the oil could be used almost indefinitely, as oil does not wear out.

Present lubrication difficulties are due to the fact that if an oil heavy enough for proper lubrication when the engine is hot is used in the crankcase at the start, it is so thick when cold that it makes the engine hard to start and does not get onto the walls of the cylinders until the car has been run several miles, whereas, if a light oil is used to avoid these troubles, it becomes too thin for safe lubrication after the engine warms up or in hot weather.

Neither kerosene nor gasoline will serve the same purpose as the carefully fractionated distillate that is being put into the experimental oil, according to Mr. Wilson. There are enormous quantities of this distillate available and the price of the prepared "non-dilution" oil should be just about the same as that of medium oils as now sold. The new type of oil has been patented and is expected to be on the market in sufficient quantities to meet the demand in another year.

Labor Saving in Tunneling[*]

Mucking Machines and Drill Cars

AMERICAN distaste for back-breaking labor has led to many inventions. Tunneling for centuries was laborious, dangerous, uninviting. Only crudest methods and tools were employed until power drills and explosives were used in rock, and power-driven shields in soft ground. Explosives have been made safer and more powerful. Compressed air has been introduced to exclude water which would otherwise come in through the interstices of the ground. Metal and masonry tunnel linings have been improved and machinery invented for placing them. With engines and boilers came steam drills, then drills driven by compressed air, and finally electric drills. Compressed air drills, however, do most of the tunneling today. Tunnels are now ventilated by power-driven fans and blowers. Electricity has made good lighting possible. Electric and compressed-air locomotives have supplanted the patient mule and the push-man. Surveying instruments and methods, too, have advanced remarkably. Tunnels can now be driven for long distances from portals or shafts, on straight lines or curves, or with angles, and the "headings" will meet exactly. Consequently, tunneling has become much more expeditious and economical, making feasible great improvements in alignment and grade of railways, highways and aqueducts. For great waterway crossing, tunnels have been preferred to bridges.[†]

In rock tunneling, holes 2 to 3 inches in diameter are first drilled in suitable number and directions then, in proper sequence, loaded with explosives and "shot." The rock is broken out and thrown in a pile of fragments and dust just where the drillers must stand to begin the next "round."

Drills, although much lighter than a few years ago, still are heavy. They have to be mounted on heavy steel columns, bars, or tripods. After the holes have been drilled, the machines have to be dragged out of range of damage. Then as soon as enough of the "muck" has been cleared away, the drilling equipment has to be lugged back over the muck and set up —back-breaking work, falling upon the drillers. It has been difficult to get and keep good men. Intelligent Americans avoid such work. Mucking is hard work, too. The smaller debris is shoveled by hand and the larger chunks lifted by men into small cars.

Rising wages, scarcity of men, and high labor "turnover" made more and more urgent the demands for power equipment. But difficulties in perfecting machine "muckers" were great—nature of the material limited space and conditions peculiar to underground operations. Nevertheless, progress has been gained by experience and partial failures. On the Moffat tunnels now being driven through James Peak of the Rocky Mountains, near Denver, for railroad and water supply, the engineers took advantage of all recent advances and went a few steps further. A practical and efficient mucking machine has been developed and installed and great improvements made in methods of drilling.

The rate at which broken rock at a heading could be loaded into cars has heretofore been the limiting factor in tunneling. Where speed was desirable and hand mucking was employed, it was common practice to level the top of the muck, mount the drills on a crossbar and drill the holes in the upper half of the face while standing on the muck. By the time this was done, the muck would be so nearly cleared that the drills could be taken down and the remaining muck thrown back so that drilling could be begun on the lower half, either by lowering the crossbar or putting up columns.

With mechanical muckers reducing at least 60% the time to clear the muck, when the drills were ready to begin operation, the mucking machine would be removing the muck on which the drillers were standing. Therefore, it was economy not to begin drilling until the muck was entirely cleared, when it was possible to lay track up to the face and thus avoid carrying the drills into the heading and setting them up by hand. The drills are now permanently mounted on a heavy car, which also carries the manifold air and water pipes for each drill, and can be pushed into the face by an electric locomotive, clamped into position and drilling commenced in from fifteen to eighteen minutes.

This, however, is not the sum total of advantages. Under the old system the drillers were usually tired before they began drilling. Under the new system the men begin drilling while they are still fresh, take greater interest in that work and make better speed. While men had to do such back-breaking work, when they accumulated a few hundred dollars, they quit the job. With introduction of mucking machine and drill car the men were no longer forced to do hard manual labor, but had merely to look after and operate machines. To most men, especially Americans, this is a congenial occupation. Hence, "turnover" has almost disappeared. As the men remain for longer periods, they become more expert. The net result has been greatly to cheapen and expedite the work. Thus has a new invention improved a whole chain of interlocking operations in tunneling through rock.

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[*] See Research Narratives Numbers 31 and 59; also "Mechanical Underground Loading in Metal Mines" by C. E. Van Barneveld, U. S. Bureau of Mines: published by School of Mines and Metallurgy, University of Missouri, Rolla, Missouri, 1924.

[†] Engineering Foundation Research Narrative, No. 111. From information contributed by D. W. Brunton, Member, A. I. M. and M. E., Consulting Engineer, Moffat Tunnel.

ENGINEERS & ENGINEERING

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The Business Situation

By COL. LEONARD P. AYRES,

Vice-President, **The Cleveland Trust Company**

SHARP breaks in the security markets, important declines in commodity prices, and the advance ruling against the proposed Nickel Plate merger have been the conspicuous developments of the past month. Nevertheless it would not be valid to infer that general business had suddenly entered upon a decline, or that most of the business news was unfavorable. Building construction, the automobile industry, and iron and steel continue to constitute the supporting tripod of the present prosperous phase of general business, and all three great industries are operating at close to high record figures.

In the case of building construction the records of 1926 are as yet too few to make possible a judgment as to the prospects for the year. This year the winter decline has been rather less than would normally be expected, and the prospects for spring activitiy seem good, although there are a good many disputes under way regarding the wages and conditions of labor in the building trades.

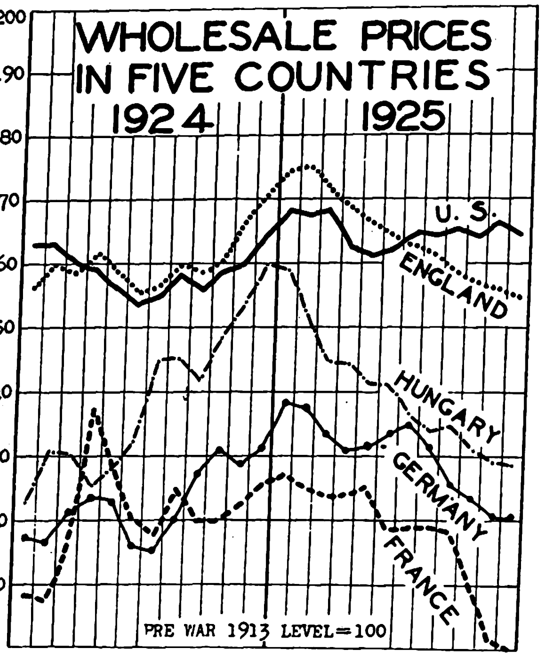
The automobile industry reported a good output in January, and an exceptionally large one in February. The prospects are that the production figures for the first three months of 1926 will be larger than those for the first quarter of any previous year. The one doubtful element in the situation is that so far the retail sales have not been keeping pace with the sales to dealers.

The iron and steel industry is producing in large volume and would be enjoying real prosperity if prices would remain firm. Unfortunately, however, the prices of iron and steel products show a tendency to soften rather than to rise.

Conditions in these three key industries are fairly typical of those in many if not most lines of business and manufacturing. Output continues to be in exceptionally large volume, but prices are tending toward lower levels, and competition is growing perceptibly keener.

Wholesale Prices

The general level of wholesale prices has been declining in this country since last November, and it is probable that this tendency toward weakness in the prices of a long list of commodities accounts for the reports that business in many lines has not been quite so good during the opening weeks of the current year as it was in the latter part of 1925. Even after due allowance has been made for the normal slowing down of business that regularly appears in the latter part of each winter, many of the current reports of trade and industry justify something of disappointment concerning present operations and earnings.



In the diagram the solid black line shows the fluctuations of the index number for wholesale commodity prices as compiled by the Federal Reserve Board during 1924 and 1925. The four other lines represent the price movements in England, Hungary, Germany, and France on a gold basis. In all five cases the lines represent the fluctuations of wholesale commodity prices above the pre-war level of 1913, which is represented by the base line of the diagram, and taken as being equal to 100.

It now seems likely that the conditions illustrated in the diagram will prove to be the most important single factor in determining the course of general business in this country this year. Prices in other important commercial countries are relatively lower than they are here, and they have been falling rapidly during the past year while ours have remained high. Now, a movement that is reducing the difference is well under way, and it seems likely that it will continue for some months to come. If this takes place general business will moderate its rapid pace, industrial profits will tend to be rather less than they were in 1925, and the recent decline of prices in the stock market will be justified by developments in trade and manufacturing.

Iron and Steel

Some signs of response to the approach of spring are beginning to appear in the iron and steel industry. Demand is perceptibly improving from a number of important consuming industries and production has moved up in a few centers. Prices, which were weak in the early weeks of the year, have held practically unchanged since the middle of February. On the whole, however, operations and buying are not as lively as they were one year ago, and output in February was still somewhat ahead of new orders. Operations range at present from about 85 per cent of capacity to 93 per cent.

Since the settlement of the coal strike in the anthracite fields the prices for coke have ceased their erratic fluctuations and this has restored blast furnace operations to nearly normal conditions. Pig iron production amounted to 104,000 tons per day during February, as compared with 107,000 tons in January, and 115,000 tons in February of 1925. At the close of the month there were 382 blast furnaces in this country available for making iron and 223, or 58.4 per cent of them, were active. This was a loss of two from the month before. Since the beginning of March several furnaces have resumed operations and it is probable that the present number active is about 60 per cent of all.

By BYRON W. HOLT,
Economist of Goodbody & Company

It is claimed by many students of the market that we have had only a moderate advance in business as compared to the rise that the stock market has had. The conclusion is then drawn that even without a decline in business a substantial reaction in the stock market is still necessary to bring stock prices into line. It would follow, of course, that if there is a business recession a more drastic decline in the stock market should occur. Such reasoning has some foundation but overlooks, first, the fact that a lower average level of interest rates is responsible for many points of the rise in investment issues and, second, that there has been a radical change in the character of the financial operations of the people of the United States, resulting in a different relation between the supply of securities and the demand for them.

On the first point, consider that a decline in average interest rates from 7% to 6% would send investment stocks up 16⅔% in price.

As to the second point, consider the United States as a creditor nation with a substantial export balance and earning large sums in the way of interest on foreign investments. Consider that we have greatly decreased requirements for funds to develop natural resources—hydro-electric development excepted—and to expand plant capacity. Consider that, owing to scientific management and better transportation facilities, the average industry requires perhaps half the inventory to do a given volume of business that it did ten years ago, and that only a portion of the funds thus freed are tied up in receivables through installment sales contracts. Also that funds are only moderately employed in speculation in commodities, and these chiefly at reasonable price levels.

It is certainly possible from these facts to draw the conclusion that even though the total supply of securities issued is larger, the supply of new investment funds which can be employed in the purchase of securities has grown proportionately more.

Corporate financing for new capital in 1925 was about $1,400,000,000 greater than in 1920. The increase can be entirely accounted for by a gain of $1,000,000,000 in new financing for public utilities, and an increase of $600,000,000 in financing for land, buildings, etc., an operation which in 1920 was almost entirely financed by banks and other financial institutions without public offerings. Foreign government loans were $350,000,000 greater in 1925 than in 1920; farm loan issues $168,000,000 greater; municipal borrowings $677,000,000 more, making total new financing of 1925 $2,600,000,000 greater than in 1920; from which should be deducted the increase in land and building loans, leaving a $2,000,000,000 gain to be offset by our greater income from foreign investments, our larger annual domestic savings and the funds freed from inventories and receivable by lower prices and a quicker turnover.

Let us concede for the sake of argument that the average level of stock prices adjusted by these various factors is not now as greatly out of line with improved business conditions as it seems, and that future stock market fluctuations will be based on the future course of business as usual. Until there is some radical change in investment conditions in this country this seems to us to be a fairly reasonable, if somewhat optimistic assumption. We have then the differences of opinion as to the course of business for the remainder of 1926 to adjust.

Business Outlook

Two of our most important industrials—the railroads and steels, depend largely for their prosperity on agriculture, building operations and, as a new factor, the automobile industry. If we can guess the outlook for these groups a reasonable forecast as to the general level of prosperity can be made.

It is, of course, too early to make any predictions, regarding 1926 crops. The 1926 cotton acreage will undoubtedly be somewhat lower owing to the prevailing lower price for that commodity. The carry-over will be at least normal, indicating little likelihood of a shortage and higher prices. The cotton growing states, with a smaller crop and no offsetting price increase, should not realize as much from cotton in 1926 as they did in 1925. As an offset, they will have additional income from the acreage this year planted to other crops.

The wheat situation is entirely in the making; it depends not only on our own crop but on the export demand, or lack of it, due to the size of the crops to be made abroad.

The corn, hogs and cattle situations are interdependent, and losses on the one hand should be offset by gains on the other.

Assuming there is no drastic upset in the wheat situation, there is no reason to expect a substantial decrease in the aggregate value of farm crops throughout the country, and any slight decrease will be offset to the farmers by a compensating decrease in the cost of living.

Commodity Prices

For, curiously enough, as many of you will be surprised to learn, the cost of living is declining. Professor Fisher's wholesale price index of 200 representative commodities stood at 153.3 for the week ended March 12, 1926, as compared with a yearly average for 1925 of 159.2; a January, 1926, average of 159.2, and a February, 1926, average of 157.6. The purchasing power of the dollar according to these indexes is thus 65.2 cents (1913 being taken as 100) as compared with 62.8 for the entire year 1925.

Many economists believe that the trend thus indicated will be continued and even intensified if mass production continues to increase, and if such minimum wages as are based on living costs can be slightly reduced.

Installment Sales and Manufacturing Costs

Defenders of installment sales are pointing out two real advantages which the system has. First, that purchases are made possible, which increase the average standard of living, with funds that would otherwise largely be carelessly spent. Second, that the volume of business made possible through installment sales permits mass production, which tends to lower unit prices and thus further stimulates consumption. If the system of installment selling were extended only to those purchases which would count with an individual as "permanent assets," these points seem to us to be well taken.

Building Activities

But returning to the subject of the general level of prosperity—the farmers having been disposed of as reasonably well fixed, the next doubtful situation we come to is that of building construction. We have been told that the building boom is shortly going to collapse; so far, however, there has been no more than a seasonal decline in the permits issued, both in New York and other cities, and the business already booked is sufficient to carry on construction activities for many months.

We accept the general belief that there will be some decline in building operations but are not by any means sure that operations will drop to a subnormal point.

The Times Annalist last week stated that "in automobiles it is clear that the industry has considerably overstocked dealers who are also bothered by a rather indigestible accumulation of used cars. The industry professes optimism as always and will perhaps be justified of its faith in the sales of the next three months. There appears to be room for some doubt, however, whether sales will move forward as the industry hopes they will."

On the other hand the leaders of the industry state that cars in dealers' hands are no more than the amount required to make prompt delivery on normal spring business. This is the period of the year when, if ever, dealers can safely be well stocked with cars. The manufacturers have production under close control and can, if sales do not materialize, cut off production rapidly enough to prevent any great accumulation. An adverse possibility is, of course, that a few of the manufacturers will leave the others to do the cutting down, and strive to maintain their own volume of sales. If this happens a period of price cutting to stimulate sales would probably ensue, which would result in unsatisfactory earnings. It would not greatly affect the industry's immediate call on the steel and allied industries for materials and parts.

The railroads thus far have succeeded in maintaining their efficiency without buying equipment or making heavy rail and structural steel purchases. There must be a limit to their capacity with present physical equipment, however, and it may be reached some time this year, so that the outlook for orders from the railroad companies, while not immediately hopeful, is fair.

To summarize, there is no reason to believe that the industrial operations contingent on farmers, building construction, motor and railroad buying, will decline more than seasonally in the next few months. The current earnings of the suppliers of these industries—particularly the steel industry, should therefore continue at a satisfactory and profitable rate.

Exports and Imports.

Our export balance which last year aggregated $681,000,000, with an excess of exports in every month of the year except July, has, in both January and February of 1926, been adverse. In January we imported $15,000,000 more than we exported, and in February $36,000,000, or a total for the two months of $51,000,000 excess imports, as compared with $137,000,000 excess exports for the same period of 1925.

We feel that an excess import balance would not be unfavorable to American industry if it were caused by increased imports and not by a contraction of exports. In the present instance, however, exports for the two months have decreased about $64,000,000, while imports have increased $124,000,000. It is said that a considerable part of the increase in imports is due to the higher price for rubber brought in and not to an increase in the volume of merchandise. Our declining exports reflect the unsatisfactory political and financial condition of Europe. If the decline continues, the failure of marginal consumption of part of the output of American industry will bring about a decided slowing down in activity. A continued unfavorable balance, plus the invisible exports, plus continued investments in foreign securities, would solve our problem of surplus funds in a way unfavorable to American securities markets. The trend of foreign trade should therefore be watched with a great deal of interest.

Railroads

The railroads continue to report a satisfactory volume of traffic and no prospect of any substantial decline because of a change in the next few months of the rate of important industrial operations or the general level of prosperity. The physical condition of the roads, reflected in lower operating ratios, is very good. There seems to be some hitch at the moment in the setting up of new wage arbitration machinery, which could be effectively used in settling the demands for wage increases now before the carriers.

The petition of the western roads for a rate increase has just been formally presented. It will undoubtedly be some time before any action is taken. Economic conditions in the northwest are not as good as they were when this rate increase was first proposed, making it possible that the opposition to it will be greater than was originally expected.

Items of Interest

DEPARTMENT OF COMMERCE
WASHINGTON

Research Fellowships

Excellent opportunities are afforded students who desire a period of active training in research work along mining and metallurgical lines through a series of co-operative agreements affected between the Bureau of Mines, Department of Commerce, and various universities and colleges for the maintenance of a number of research fellowships. For the college year 1926-1927 more than thirty fellowships in eight institutions will be awarded. The problems to be studied cover a wide range of scientific research. Many students who have received these fellowships in past years have, as a result, obtained remunerative positions in the industrial field. Detailed information in regard to the terms of the different fellowships can be obtained by applying to the authorities in charge of the educational institutions named below:

The School of Mines, College of Engineering, University of Alabama, Tuscaloosa, Ala.

The Department of Mining and Metallurgy, College of Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

The College of Mines, University of Washington, Seattle, Wash.

The Arizona Bureau of Mines, College of Mines and Engineering, University of Arizona, Tucson, Ariz.

The Department of Mining and Metallurgical Research, University of Utah, Salt Lake City.

The School of Mines, University of Idaho, Moscow, Idaho.

The School of Mines and Metallurgy, University of Missouri, Rolla, Mo.

The Mackay School of Mines, the University of Nevada, Reno, Nevada.

May Run Automobiles on Fuel Oil

That the day is almost within sight when automobiles, airplanes, trucks, tractors, motorcoaches, railcars, tugs and pleasure craft may be driven by heavy-oil engines, with a low cost of power production that never could be dreamed of with the gasoline engine, was indicated at the annual meeting of the Society of

Automotive Engineers by the account given by A. C. Attendu, a consulting engineer of Montreal, of the development of small, lightweight engines of this type by himself and the Eastern Engineering Company of Montreal.

The latest of these is an experimental aviation engine built for the U. S. Navy Department. This weighs only 417 pounds and has developed 91 brake horsepower at 1525 revolutions per minute. Changes that are now being made are expected to increase the power output to between 110 and 116 brake horsepower and reduce the fuel consumption to one-half pound per brake horsepower per hour.

All of the experimental engines were designed to be built of materials and by machinery now in use by automobile manufacturers and so that all parts would be as interchangeable as are the parts of automobiles of the same model.

The first engine was built in 1921 of cast iron with four cylinders and weighed 1,100 pounds. Tests made at McGill University led to the decision to build a second engine with solid fuel injection instead of air injection. This also was a four cylinder engine made of cast iron and had a compression pressure of 405 pounds per square inch. It was of two-cycle type, had step cylinders for scavenging the combustion chamber and ran on the same fuel as the first engine.

In preliminary runs this second engine started on the first few revolutions, attained a speed of 1,600 revolutions per minute and developed 18 brake horsepower. After various changes were made it developed 56 brake horsepower at 1,400 revolutions per minute. The fuel consumption is at the rate of two-thirds of a pound per brake horsepower per hour, the engine idles down to 120 revolutions per minute and starts readily from dead cold after three to five revolutions with a six-volt starter.

Three engines of this type were built and a car fitted with one was operated about 3,000 miles during the summer of 1924 without the slightest trouble. Two-thirds of this distance was run on a dirt track at an average speed of 27 miles an hour and the fuel consumption was at the rate of one imperial gallon per 23¾ miles. The car, fully loaded, weighed 5,100 pounds.

Life of a Steel Building Framework

The most important, if not the only, survey of the condition of the metal framework of a large building after more than three decades of service has been published by the American Institute of Steel Construction in a booklet entitled "Madison Square Garden. One of New York's Architectural Landmarks."

The survey was made during and following demolition by Frank W. Skinner, Consulting Engineer of New York City, and thoroughly covers the condition of the structural iron and steel in the old Madison Square Garden. Mr. Skinner's investigations show that all of the structural iron and steel, with the exception of a relatively small proportion under special and unusual conditions in the main tower, was found in a perfect state of preservation.

Copies of the booklet may be obtained through Engineers and Engineering.

Papers Read Before Local Engineering Societies and Local Sections of National Societies

We shall publish each month a list of the more important of such papers. Some of these never appear in print but are available in typewritten form. Secretaries are urged to submit titles of papers, names of authors and a brief synopsis of each paper setting forth any points of especial value to the profession. If copies of papers of exceptional value and interest are mailed to us we shall be glad to publish reasonably full synopses or the papers in entirety.

BOSTON, The Boston Society of Civil Engineers

The Coal Situation, Eugene C. Hultman
Hydrogen-Ion Control in Chemical Treatment of Wastes, Stuart E. Coburn
A Plant for the Degreasing of Wool-Scouring Wastes, George G. Bogren
Some Effects of "Cal" on Cement and Concrete, Miles N. Clair
The Sanitary Conservation and Utilization of Water Resources, W. L. Stevenson
Stresses in a Composite Member Subjected to Bending and Direct Stress, B. A. Rich and W. W. Bigelow.

BOSTON, The Affiliated Technical Societies of, Volume of following 10 papers, with discussions, delivered at two-day session December, 1925. $1.00

Coal—The Basic Fuel, F. H. Daniels
Supply and Utilization of Fuel Oil, E. H. Peabody
Diesel Engines for New England Power Plants, J. F. Hecking.
Possibilities of Obtaining Power from Public Service Corporations, L. R. Nash
Power for Textile Mills, Charles T. Main
Power for the Paper Industry, Joseph A. Warren
The Utilization of Power in the Typical New England Plant, K. D. Hamilton

Advantages and Disadvantages of High Steam Pressure in Industrial Plants, Joseph Pope
Utilization of Extraction Steam, E. D. Dickinson, A. D. Somes and R. G. Standerwick
The Supply of Industrial Power, W. H. Larkin, Jr.

BROOKLYN, N. Y. Brooklyn Engineers' Club
The Design and Construction of the Bear Mountain Bridge over the Hudson River, Harry D. Leopold
The Installation of a Coal Handling, Screening and Storing System at the Nassau Works of the Brooklyn Union Gas Co., Linford S. Stiles
The New Floating Dry Docks at the Plants of the Sun Ship Building Co. and the Federal Ship Building Co. Built in Record Time, David W. Barnes

BUFFALO, N. Y. Engineering Society of Buffalo
Winter-built Concrete, Portland Cement Association (with bibliography),
Practical Points for Cold Weather Work, Turner Construction Co.

CHICAGO. Western Society of Engineers
Waste Heat Boilers in Steel Mills, F. H. Willcox and J. C. Hayes.
Bond and Anchorage in Reinforced Concrete Beams, T. D. Mylrea
Recovery of By-Products in the Gas Industry, Chester S. Heath

IOWA. The Iowa Engineering Society, Ames.
A Study of Road Failures in Northeast Iowa, Q. C. Ayres
Surety Bonds and Their Relation to the Construction Industry, C. Moriarty
Rainfall and Runoff in Illinois, C. H. Young
Erosion and Its Prevention, Chas. E. Gross
Landscaping of Highways with Special Attention to Safety of Intersections, P. H. Ellwood
Iowa's Three Year Road Program, Fred R. White
The Use of Oil and Calcium Chloride for the Maintenance of Earth and Gravel Roads, H. F. Clemmer
Surface Treatment of Secondary Roads, Geo. E. Martin
Disposal of Special Wastes, Dr. Max Levine
Selection of Pumping Equipment, N. L. Veach
The New Des Moines Power Plant, R. K. Lane
City Planning Accomplishments in St. Paul, Geo. H. Herrold
Rural Electrification, Frank D. Paine
Diesel Engine Operated Cars, A. H. Candee
Iowa Roads: Who Shall Pay and How? W. G. Raymond
Johnson's Mortar Mix, E. Townsend
Summer Surveying Camps, John S. Dodds

MINNESOTA. Minnesota Federation of Architectural and Engineering Societies, St. Paul
The St. Paul Union Depot, G. H. Wilsey

PHILADELPHIA. The Engineers Club of
Present and Future of Motor Car Fuels, H. H. Hill
Gasoline Substitutes from Coal, A. C. Fieldner
Mechanical Design to Realize Best Economy of Fuel Supplies, S. W. Sparrow
Power Transmission Economics, William Staniar
Lubrication and Bearings, John D. Gill
Economy Due to Power Factor Correction, Erb N. Dittenhofer
Plant Illumination, Ward Harrison
High Pressure Prime Movers in Industrial Plants, Francis Hodgkinson
The Use of Exhaust Steam for Process Work in Textile Plants, Samuel M. Green
Heat Insulation, L. B. McMillan
Heat Insulation, R. H. Heilman
Economic Factors Governing the Purchase or Generation of Power, William A. Shoudy
Operating a Private Power Plant in Competition with Purchased Power, Thomas V. Balch
Operating with Purchased Power in Competition with Private Power, Reginald P. Bolton
The Present and Future of American and Foreign Air Service, C. M. Keys
Airways and Airdromes, Colonel Paul Henderson
Heavier Than Air Craft, William Bushnell Stout
Lighter Than Air Craft, Captain George W. Steele, U. S. N.
U. S. Post Office Air Mail Service, Chase C. Gove
Civil Aviation in Great Britain, Major-General Sir Sefton Brancker
Legal Aspects of Air Transportation, William P. McCracken
Research and Its Application to Engineering, Dr. Geo. H. Hoadley
Our Country's Interest in the Pacific, Dr. Jeremiah W. Jenks
Atlantic Deeper Waterways, Hon. J. Hampton Moore

PHILADELPHIA, Amer. Soc. for Steel Treating
Relationship of Metallurgy to the Development of the Airplane, J. B. Johnson
Procedure of Correct Hardening, Gordon Korp
The Applied Metallurgy of Alloy Steels, Henry T. Chandler
What Happens When High Speed Steel Is Quenched, F. R. Palmer
Malleable Cast Iron, H. A. Schwartz

PHILADELPHIA, Assn. of Iron and Steel Elec. Engrs.
The Application of High Duty Worm Gears in Steel Plants, Arthur Henthorn
Purchased Power Rates, D. N. Petty
Magnetic Control for Steel Mill Auxiliaries, H. H. Engel

PHILADELPHIA, A. I. E. E.
Automatic Control Equipment
New Developments in Supplying Electric Power to Downtown Philadelphia, H. S. Davis and C. L. Gilkeson

PHLADELPHIA, Amer. Welding Soc.
Preparation of Material for Welding, E. E. Thum
Seam and Roller Welding, W. A. Gibb
Automatic Arc Welding and Its Benefits to the Welding Art, H. M. Hobart

PHILADELPHIA, Soc. Amer. Military Engineers
War Films, Capt. William H. Crosson, U. S. A.
War Films, Capt. William H. Crossan, U. S. A.
The Program for Transit Development and the Design and Construction of the Broad Street Subway by the City of Philadelphia, Henry E. Ehlers, Paul G. Brown, John S. McDonald

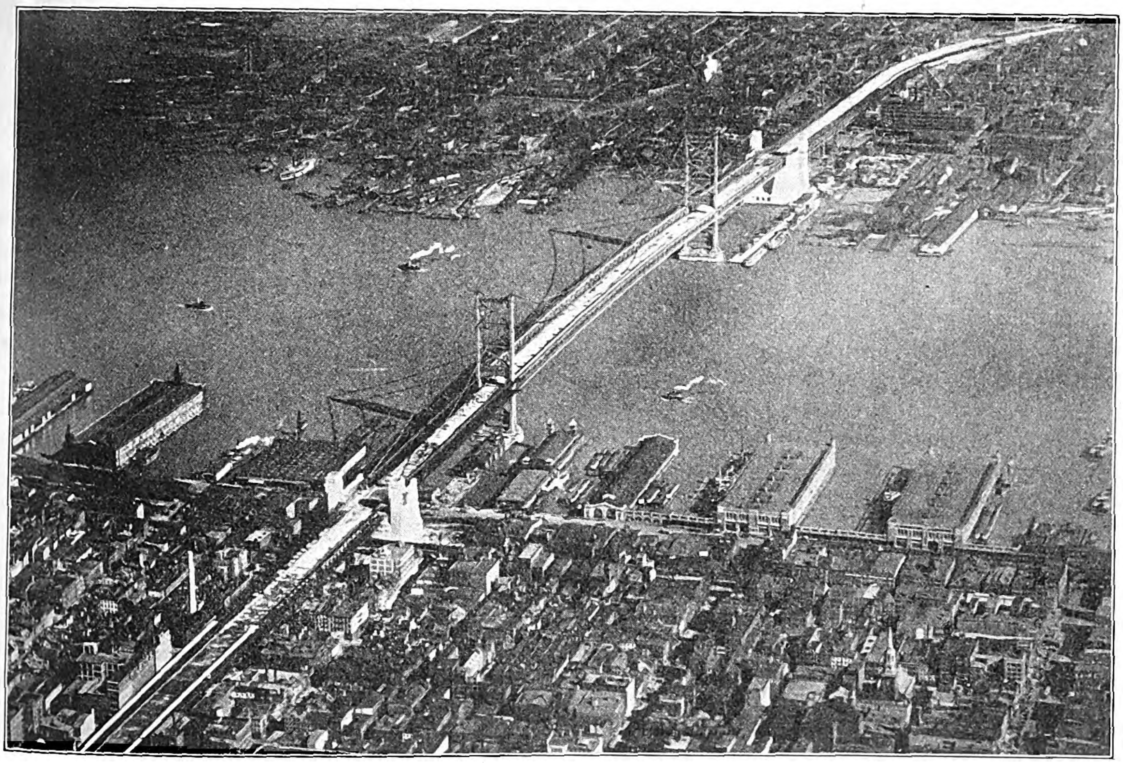
PHILADELPHIA, Amer. Soc. Heating and Ventilating Engrs.
Rating and Testing Radiation, R. V. Frost
Proportional Domestic Hot Water Heat Supply for Summer and Winter, Charles Hansen

Tolls Dispute Settled and Contracts Awarded for Completion of the Delaware River Bridge*

PROGRESS on the Delaware River Bridge since January has included settlement of the tolls dispute between Pennsylvania and New Jersey and the placing under contract of the work required to provide for opening the bridge to traffic on July 4, 1926.

Settlement of the tolls dispute, which had caused the suspension of further contract awards since September, was effected in February when the Legislature of Pennsylvania passed, and Governor Pinchot approved, a bill providing for the collection of tolls. This action repealed the law passed in 1925 requiring that the bridge be forever free of tolls. The tolls dispute resulted from that law, when the city authorities of Philadelphia claimed that it prevented the collection of tolls by New Jersey. The bond issues of New Jersey by which the work was partly financed had stipulated that the revenues from the bridge were to be used for their refunding. This requirement had been interpreted by the New Jersey authorities as making toll collection mandatory and the bonds had been approved by a referendum vote with that understanding. The Philadelphia claim caused the New Jersey commissioners to refuse to award the contracts required to complete the bridge until the right to collect tolls was recognized by Pennsylvania. Following this action by the New Jersey commissioners, Pennsylvania entered suit in the United States Supreme Court to compel completion of construction by New Jersey. At the same time the *Philadelphia Record* undertook a private poll of Pennsylvania sentiment toward toll collection, which resulted in indicating a great majority both in Philadelphia and throughout the state in favor of tolls. The action of the Governor and legislature at the special session conforms with the sentiment thus indicated and ended the deadlock.

After the passage of this bill, the Joint Commission began consideration of a tolls agreement between the States and on March 5th approved a compact providing a basic charge of 25 cents per passenger automobile and providing for later decision on truck and wagon tolls. Charges to be levied on passenger transportation lines are expected to be made the subject of special agreements between the Commission and the utility companies that may operate such services.



Aerial View of Entire Span—March 4, 1926

The contracts for completion of the work required to open the bridge to traffic were awarded during March, as follows:

Contract	For	Date of Award	Contractor	Amount
22B	Excavation Phila. Approach	March 5, 1926	Richards-Kelly Co.	$ 15,300.00
24	Miscellaneous Metalwork	March 5, 1926	Ford & Kendig Co.	622,000.00
25	Electrical Equipment	March 5, 1926	W. V. Pangborne & Co.	209,626.00
26	Wrapping the Cables	March 5, 1926	Keystone State Corp.	139,000.00
27	Camden Approach	March 5, 1926	O'Neill Company	150,460.20
28	Camden Approach	March 19, 1926	O'Neill Company	251,888.95

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*Contributed by Charles Carswell, Assistant Engineer, Delaware River Bridge Joint Commission.

CONSERVATION OF FUELS FOR MOTOR VEHICLES

Discussed at a Joint Meeting of

The Engineers Club of Philadelphia
The American Society of Mechanical Engineers (Philadelphia Section)
Society of Automotive Engineers (Philadelphia Section)
Held at The Engineers Club, January 19, 1926

(Continued from page 80, March issue)

Availability of Petroleum Substitutes from Coal

By MAJOR A. C. FIELDNER,

Superintendent Pittsburgh Experiment Station, Bureau of Mines, Department of Commerce

MR. HILL, my colleague in the Bureau of Mines, has pointed out most admirably the excellent work that is being done by petroleum refiners in increasing the yield of gasoline and by the drillers in recovering and conserving more of the oil that we get from the ground and the splendid efforts of the automotive industry to make one gallon go as far as two gallons now go.* But, if you will refer to the report of the Committee of Eleven of the American Petroleum Institute, recently published, you will find we are today living on the cream of our motor fuel supply. In summarizing the resources of the United States, they estimate 5 billion barrels of petroleum in the ground that is recoverable by present drilling and pumping methods and another 25 billion barrels that remains in the ground, unrecoverable by present methods, but of which a considerable proportion may be obtained in the future by improved methods of pumping and by mining the oil sands. No attempt was made to estimate the number of barrels of petroleum that is in the ground yet undiscovered.

The Committee next estimates 107 billion barrels of liquid fuel to be obtained from oil shale and then 545 billion barrels of petroleum substitute—not gasoline substitute—which may be obtained from coal by distillation processes and, finally, 70 billion barrels by processing the lignites of the United States.

Now think of the proportion—5 billion barrels of petroleum in sight and then some 700 billion barrels in solid form that must be recovered by processing methods. Obviously, the great bulk of the committee's petroleum supply is certainly not cream; it is skimmed milk, and it is bound to be much more costly than the gasoline we get from petroleum. And then there is the more important question of the availability of this 700 billion barrels. Is it available if our flush production suddenly ceases? Mr. Hill has said that flush production accounts for 85 per cent of our current petroleum supply. Is this figure correct, Mr. Hill?

MR. H. H. HILL: Eighty-five per cent is from the newer fields.

MAJ. A. C. FIELDNER: Suppose that flush production fell off suddenly and we were obliged to obtain oil substitutes from coal and oil shale. It is my purpose to discuss briefly the availability of this material, in the present light of knowledge regarding methods of procuring gasoline substitutes from coal and shale, more especially from coal.

Methods of Obtaining Motor Fuel From Coal

In 1924, the gasoline consumption was about 7700 million gallons. We have four possible methods for obtaining motor fuel substitutes from coal: First, carbonization of coal in our present types of by-product coke ovens and gas retorts; second, the low-temperature carbonization of coal; third, the hydrogenation and liquefaction of coal by the Bergius process; and, fourth, the complete gasification of coal and conversion of the resultant gas into synthetic liquid fuel. Of these four types of processes the first is the only one that is being carried out on a large scale. The others are possible processes which may come into use in the future.

Low-temperature carbonization of coal is not an existing commercial process today anywhere in the world unless, perhaps, in the brown-coal distillation plants in Germany. There are, however, a number of low-temperature carbonization experimental plants operating intermittently in America and abroad. The third method, the hydrogenation and liquefaction of coal by the Bergius process, in which the greater part of the coal is converted into a liquid form similar to crude petroleum, has been subject to laboratory investigation in a number of European laboratories and is now being tried with a large scale unit by Bergius at Rheinau, near Mannheim, Germany. The fourth method, that of completely gasifying coal by making water gas and converting the water gas, with additional hydrogen, into liquid fuels, is just appearing on the horizon in research laboratories. As you know, methanol or wood alcohol is now made on a commercial scale from carbon monoxide and hydrogen, by the Badische Anilin und Soda Fabrik. The successful synthesis of methanol opens up a new field of synthesizing motor fuels from gas and may lead to the ultimate solution of the problems of future gasoline substitutes.

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*See March, 1926, issue "Engineers and Engineering," page 85.

Let us return to a consideration of what proportion of our gasoline requirement might be obtained from existing methods of carbonizing coal in byproduct coke ovens and gas retorts. The entire yield of benzol from gas and coke plants for the year 1923 amounted to some 135 million gallons, 1¼ per cent of the gasoline requirements of 1924. If the yield from coal carbonized in beehive ovens is added to this figure, it is increased to 2 per cent of the gasoline requirement and, if all the bituminous coal mined in 1923 had been carbonized and the light oil recovered, it would amount to only 1,335 million gallons, or 18 per cent of the gasoline requirement of 1924. Obviously, the existing methods of carbonizing coal are inadequate to furnish any material proportion of the gasoline requirement for it is not possible greatly to enlarge the coal carbonizing capacity of the country because such capacity is determined by the coke and gas needs which are the main products of these processes. Therefore, these industries can not materially augment the motor-fuel supply in case of a rapid falling off in flush production of the oil wells.

Yields From Low-Temperature Carbonization

In the low-temperature carbonization process, the coal is heated, in round numbers, to 1200° F. as in the high-temperature process. Because of the lower temperature, the primary tar of the coal is liberated and removed from the oven with much less decomposition into secondary products, gas, carbon, and low molecular weight compounds. The tar yield is from 20 to 30 gallons instead of from 10 to 12 gallons per ton of coal. The tar resembles asphaltic petroleums in some respects and has about the same consistency and specific gravity. It contains paraffin, naphthene and unsaturated compounds similar to those found in petroleum. It does not contain benzol, toluol, naphthalene, anthracene and carbolic acid, found in high-temperature tar. The average yield of light oils, by direct distillation of the low-temperature tar and by scrubbing the gas, is in the neighborhood of 3 gallons, about the same as obtained from high-temperature carbonization. It is possible, however, to crack these 30 gallons of low-temperature tar and convert a portion of it into light oils which may be used as motor fuels. Laboratory figures indicate that some 20 per cent may be converted into motor fuel. We might, therefore, look forward to a total yield of 6 gallons of motor fuel by low-temperature carbonization of one ton of coal.

Now why should the industry take up low-temperature carbonization of coal under present economic conditions? Is this yield of gasoline and oil sufficient to make this process a profitable proposition even if the prices of oil were higher, such as might prevail when petroleum becomes scarce? It is rather doubtful whether the increased returns from the tar and light oil of a low-temperature plant will be sufficient to increase greatly the number of low-temperature carbonization plants for this reason alone. There must be some other reason tied up with it. Two reasons appear upon the horizon: One is the demand for a smokeless solid fuel for domestic use and the other is the pretreatment of coal for gas and oil recovery in conjunction with steam generation in large central station power plants. It is true that cokes, byproduct and gas coke, are smokeless fuels and may be used as substitutes for anthracite. Probably some of you are now using such substitutes during the anthracite strike. If you are, you will recognize certain disadvantages. Metallurgical coke does not ignite as easily as anthracite. It is rather porous; the furnace must be charged more frequently and the combustibility of the coke is less. On the other hand, low-temperature coke, because of the 8 to 12 per cent of volatile matter which it retains, is also smokeless, ignites readily, and burns with a short flame.

Prospects for the Future

It seems reasonable to expect that in the future a desirable smokeless fuel can be made by low-temperature processes. The problem is largely one of economics and mechanical design of suitable equipment. In most of the processes thus far developed, the output is too small per unit of equipment, thus entailing large fixed charges. In high-temperature carbonization, heat is driven into the coal from a high-temperature gradient which causes a much faster rate of carbonization than takes place in low-temperature carbonization where the gradient is much lower. Therefore the layers in low-temperature retorts must be thinner, the fuel charge must be agitated, or heat must be put into the coal by means of preheated gases or steam. Future development must be along the line of larger output per given installation cost. We may be nearing that point now. Certainly several different experimental plants now operating could make a profit at the present abnormal prices for coke prevailing in New York and Philadelphia but in normal times they could not do so. However, let us assume that a low-temperature carbonization process is developed for smokeless fuel and estimate the quantity of such fuel that can be marketed. In round numbers, our annual production of anthracite is 90 million tons and this quantity of smokeless fuel would provide 7 per cent of the 1924 gasoline requirement. Assume that central power stations also pretreat their coal. The 60 million tons of coal per year consumed for generating electric power would provide 5 per cent of the 1924 motor-fuel requirement. This means a total of 12 per cent of the motor fuel requirement may be had from a reasonable development in low-temperature carbonization.

Even if all the coal mined were processed, after deducting that needed for the metallurgical and gas-making industry, the yield would be only about 40 per cent of the 1924 gasoline requirement. Certainly such a development can not take place in the immediate future, in case of sudden diminution of flush petroleum production. We must rather turn to the remaining two processes which permit, if developed, the conversion of the greater part or all of a ton of coal into liquid products. Of these processes the Bergius process is perhaps the most promising.

The Bergius Process

The Bergius process was first described about 1912 or 1913 by Dr. Friederich Bergius, of Germany. He was a student of Prof. Fritz Haber, who did the early work in the synthesis of ammonia from nitrogen and hydrogen under high pressure. Bergius found that when powdered coal is heated in a steel bomb to a temperature of about 750 degrees Fahrenheit, with hydrogen under a pressure of 150 atmospheres, it is converted into a liquid form. This liquid is similar in many respects to petroleum and can be distilled and fractionated to a fair yield of oils to the extent of 30 to 70 per cent of the weight of the coal. In the summer of 1924, I visited the Bergius experimental plant at Mannheim, Germany, and saw a semi-large-scale pressure retort in operation. The capacity of this retort was 2 tons of coal per 24 hours. The experimental tube of heavy-walled steel was about 8 inches in diameter and 9 feet long. It was heated by burners underneath to a temperature of about 750 degrees Fahrenheit. The coal was pumped into the tube continuously in the form of a thick paste, the powdered coal being mixed with either tar or petroleum. The treated material, a fluid black liquid, was discharged continuously at the opposite end of the tube, through a suitable pressure reducing device. Of this liquid about 15 per cent, or 40 gallons per ton of coal, could be distilled off for motor fuel. The total yield of crude oil was approximately 140 gallons, from which may be obtained 40 gallons of motor fuel, 50 gallons of oil suitable for Diesel engines, 35 gallons of fuel oil, and a pitch residue.

The cost of the process is unknown because of uncertainty of the life of the steel pressure retorts. These are expensive and may not last over a year. Bergius thinks they should last 5 years. According to a personal communication from Dr. Bergius, he is now experimenting with a much larger retort, one with a capacity of 40 or 50 tons of coal per 24 hours. There were some newspaper accounts of a large plant to be erected in eastern Germany but later reports stated that the project failed to materialize. Bergius claims that, if the retorts have a life of 5 years as he predicts, then the process can compete with imported petroleum at the present-day prices in Germany, which means about $6 a barrel.

Not all coals respond to the Bergius treatment. The best results of about 70 per cent conversion were obtained with a high-volatile non-coking coal. Excellent yields were also had from low-temperature coke from German brown coal. No experimental data are available on the yields that may be had from American coals but enough work has been done on British and German coals to indicate that many American types of coal would give equal yields to those obtained at Mannheim. And then there is the further possibility of hydrogenating low-temperature tar and obtaining additional motor fuel.

A source of cheap hydrogen would be a great aid to the commercial development of this process. Pure hydrogen is expensive. Bergius therefore proposes to use lean coke-oven gas, which contains some 70 per cent hydrogen. He is quite confident that the process will operate on 70 per cent hydrogen, that it will merely require higher total pressures.

Synthetic Motor Fuel From Water Gas

The fourth process for obtaining motor fuel from coal is by synthesis from gases as, for example, carbon monoxide and hydrogen. The Badische Anilin & Soda Fabrik in Germany is now making methanol from carbon monoxide and hydrogen on a commercial scale. Two volumes of hydrogen and one volume of carbon monoxide are compressed to from 150 to 200 atmospheres and pumped into cylinders heated to a temperature of about 750 degrees Fahrenheit and containing a catalytic material, said to be zinc oxide plus certain other metallic oxides. Under these conditions pure methanol, wood alcohol, is obtained. Iron must be absent; the catalyst chamber must be lined with copper. The Department of Commerce states that 187,700 gallons of synthetic methanol were imported into the United States during the first 10 months of 1925. The actual manufacturing costs are said to be from 13 to 18 cents a gallon in Germany.

Audibert and Patart, in France, have also published articles on a similar process with similar yields and research is in progress that will undoubtedly establish a methanol industry in this country. Coal and water are the raw materials for the manufacture of methanol, the carbon monoxide and hydrogen being obtained from water gas which consists of approximately equal parts of these gases and is made by the action of steam on incandescent coke. The extra hydrogen required is obtained by passing a part of the water gas, mixed with steam, over a heated nickel catalyst whereby the carbon monoxide is converted to carbon dioxide and the steam into hydrogen. The carbon dioxide is washed out of the mixture and pure hydrogen remains. A water-gas generator making 960,000 cubic feet of hydrogen will yield 2,500 gallons of methanol. The cost should be less than 20 cents a gallon.

According to an English authority, if water gas costs 16 cents per 1000 cubic feet and hydrogen 60 cents, the raw materials for methanol would be 8 cents a gallon. Obviously, we have here at least one process whereby coal or rather coke can be completely converted into a possible gasoline substitute. It is true that methanol is a low-grade substitute, but it can be used in automobile engines of suitable design. Unfortunately, methanol does not blend with gasoline, so that it can not be mixed with it unless a third blending constituent can be added. If that can be done, this methanol process is a very likely one for augmenting gasoline supply in case of need, because water-gas generation and the manufacture of hydrogen are well-known processes. The pressure reaction process is not unlike the synthetic ammonia process, which is taking an important place in our industrial scheme. However, to a chemist, the methanol process is of most interest because it points the way to similar synthesis of other liquid combustibles from gases.

Franz Fischer at Mulheim-Ruhr, Germany, has been studying reactions of this type with other catalysts and has obtained a synthetic fuel which he calls "synthol," and which is a mixture of alcohol, aldehydes and hydrocarbons. He obtains about 30 per cent of the heating value in the gas in the form of a refined motor-fuel suitable for use in a gasoline engine. It has a boiling range similar to that of gasoline and therefore is suitable for use in present-day types of gasoline engines. Although Fischer's experiments were made on a small scale in the laboratory, they indicate the possibility of making synthetic motor fuels of characteristics similar to gasoline. A number of other investigators are now entering this field of research and I feel safe in predicting that other discoveries will be made along the line of converting gases from coal into volatile combustible liquids.

From the point of view of manufacturing motor fuel only, these processes are the logical solution of the problem because there are no other by-products except possibly a residual gas but, for complete substitutes for petroleum itself, that is, not only gasoline but fuel and lubricating oil as well, the Bergius process seems the most suitable besides being farther advanced in large scale development. Several workers in England and others in Germany have definitely verified the essential results reported by Bergius. The process needs only further work in the mechanical and metallurgical side of the problem involved in building suitable pressure retorts and, then, a great help would be a cheaper method of producing hydrogen. Such a process would also be capable of quick expansion in case of diminution of flush production of petroleum.

Other Sources of Automotive Energy

In conclusion, I can not avoid sounding a note of warning by saying that other fuels and forms of energy may play a very important part in augmenting a failing gasoline supply. If synthetic gasoline from coal costs too much, coal- or coke-burning boilers and steam engines may be placed on trucks. Such trucks, or "steam lorries," as they term them, are still found in England. Also charcoal-burning gas producers furnish the fuel for trucks in certain parts of Europe and Africa and, then, there is, of course, the Diesel engine which uses heavy oils and tars directly without expensive processing. Considerable work is being done in Germany on the development of the Diesel engine for motor trucks; in fact, the Diesel engine is the logical apparatus for low-temperature tar. The entire 30-gallon yield from a ton of coal could be used without further refining or loss in such automotive equipment. And finally, we must not forget the electric storage-battery. Radical improvements may make the storage-battery the ultimate solution of our problem. Storage-battery stations, where you can drive up, have them pull out your old battery and put in a charged one in less time than it takes to fill the tank with gasoline, may take the place of the filling stations. I can not help feeling that some of these other forms of energy are, in the last analysis, more likely to supersede the gasoline engine than expensive processing calculated to produce a fuel identical with our gasoline of today.

(Record of meeting continued on next page)

Mechanical Design to Realize Best Economy of Fuel

By S. W. SPARROW

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IT IS my purpose merely to bring to your attention a few of the factors which influence the fuel consumption, that is, the miles obtainable per gallon of fuel, by the ordinary motor car.

One of the oldest units of transportation is the camel. The ordinary mortal does not know whether the camel is strong or weak, whether he is fast or slow, whether he is good-natured or grouchy. One thing only he knows, and that is he can cover long distances on a single drink. If people have that much interest in an ancient method of transportation, surely they should be interested in that more modern means of transportation, the automobile; they should be interested to know the distance it can cover on a unit amount of liquid and the reasons why.

The previous speakers have held out, as their hope and as the job of the automotive engineer, the doubling of the mileage to be obtained from a gallon of fuel. If that is done, it will probably have to be done by sacrificing a certain amount of performance. It is almost the conventional opening, in a talk of this kind, to point out that, if we could educate the public to be contented with a little less speed and a little less flexibility and to be willing to shift gears a little bit more frequently, great improvements in fuel economy could be obtained. While that may ultimately be necessary, it does not seem to me that it should be the starting point in our endeavor to save fuel. If you wish to explain to a man how he can decrease the cost of his dinner, he will be interested but, the minute you tell him he must decrease the cost by decreasing the size of the dinner, his interest wanes. I do not believe we should start in saving gasoline by sacrificing performance or demanding less. I do not believe that in that direction is the real pathway to progress.

The Real Theme

In the first part of the discussion the real theme, I think, might be suggested by two questions. The first question is: How far *can* the average automobile travel per gallon of gasoline? The second question is: How far *does* the average automobile travel per gallon of gasoline? I think we have a right to expect that the future is going to see a great deal of development along the line of increasing what can be done, the miles the car can travel per gallon of fuel, but I have a feeling that the greatest improvement we are likely to see will come from decreasing the difference between what the average car can do and what the average car does do.

For a starting point, suppose we consider first what governs that particular difference. I thing, in general, the difference lies in the difference between the mixture ratios, that is, the amounts of fuel and the amounts of air, that the engine receives and that it requires. First of all, let us consider what really governs the requirements of the average motor car. If the fuel is a hydro-carbon fuel, as it usually is, and we know the percentages of carbon and hydrogen which it contains, we can figure out the amount of air that must be supplied in order to get complete combustion. It is really the amount of oxygen in which we are interested, oxygen being the active constituent of the air and we find that for gasoline, for example, we need a ratio of 15 pounds of air per pound of fuel. This is what is known as the chemical combining ratio. Both theory and practice tell us that, if we wish to get the maximum amount of energy out of a unit weight of air, which is the requirement for maximum power, we must supply a somewhat greater amount of fuel, and if we wish to get the maximum amount of energy out of a given weight of fuel, which is the requirement for best economy, we must use an excess of air. As a matter of fact, theoretically, we get the best economy when we have used the least amount of fuel with which we can get an explosion. In actual practice you ordinarily cannot go quite that far because, as you decrease the fuel content of the mixture, you decrease the rate at which the mixture will burn and, eventually, you will reach a point where the time required for combustion occupies so much of the time available for the working stroke that the energy is not developed until it is almost time for the charge to be exhausted and a loss in power is the result. So we have the contrast between the maximum power mixture and the mixture for maximum economy.

Now, for any particular engine, we can determine comparatively easily, for any particular set of conditions, just what actual mixture gives the maximum power and what mixture gives the best economy. We will find that, for different engines, and for different conditions with the same engine, these values will differ. The reason for those differences in general is this: When we talk about mixture ratio requirements, we are talking about the mixture in the engine cylinder, which is not necessarily the mixture supplied by the carburetor. If all the fuel is not vaporized under the temperatures of operation, the carburetor must supply some excess fuel in order that the amount that is vaporized will be sufficient to give the desired mixture ratio. If, in your multi-cylinder engine, each cylinder does not receive the same charge, then you must supply excess fuel to some cylinders in order that the weakest one may receive enough. If one cylinder for some reason has a little bit more exhaust gas left in it than another, you must supply excess fuel to take care of that condition. In short, engine operation under conditions of poor vaporization and poor distribution is made possible very largely by adjusting the carburetor to furnish sufficient excess fuel to ensure a combustible mixture in every cylinder.

Now, while these differences are very great, yet we find one relationship which remains relatively constant and that is the relationship between the point at which we obtain the maximum power and the point at which we obtain our best fuel economy. If you lean the mixture, that is, decrease the fuel content until you get what is approximately the best economy, you will find you have in general about 95 percent of the maximum power and that is a good rough figure to allow if you are going to calculate an aviation engine, for example, on the basis of using at all times the maximum economy mixture.

Maximum Economy or Maximum Power?

And now, what shall we use in the engine? Shall we use the maximum economy mixture, or the maximum power mixture? I think, for part throttle conditions, the answer is fairly simple, namely, that we should use that mixture which under all conditions will give the best economy.

A salesman once approached a farmer and offered for sale a special food for his hogs. The chief point the salesman stressed was that this particular food could be digested in half the time required by ordinary fodder. The farmer listened very patiently and, when the torrents of oratory had subsided, asked the salesman, "How much do you think a hog's time is worth?"

I think the same reasoning applies in this engine condition. There is no particular point in supplying a maximum power mixture—that is, a mixture which gives the greatest amount of energy for a unit of volume—when, by merely opening the throttle a little more, we can get all the energy we need and get it cheaper in that fashion.

To the question of the maximum power condition or the full throttle condition, the answer is not so simple. If we set up as our basis a given standard of performance and consider first an engine using a maximum power mixture and delivering a certain amount of power and then another engine using the maximum economy mixture and just enough larger to give the same power as the first one, the second or bigger engine, I feel pretty confident, would give an over-all economy superior to the first. On that basis, probably the best economy mixture would be desirable at full throttle if we could insure that throughout its life the engine would be supplied with that mixture. When this engine gets into the hands of the user, however, he, being human, probably will never be satisfied until he gets "all there is and there isn't any more;" so that the chances are, if there is any possible way in which he can adjust the carburetor to give the maximum power mixture and hence a little bit more power, he will do so. If the carburetor is constructed to deliver the *same* mixture, the best economy mixture, at full and part throttle, then, if adjusted to give the maximum power mixture at full throttle, it will necessarily give it also at part throttle and poor economy will be the inevitable result. So that, in general, I think we can say our requirements had best be the economy mixture, for all conditions other than full throttle, and during acceleration which is a condition very similar.

Now the difficulty of finding whatever particular mixture is desired under any condition is not great; that is easy to do, if you have time and patience; but to supply that mixture under all conditions, with a minimum inconvenience to the operator, is a rather difficult problem.

Let us meditate for a moment on the job the carburetor has and consider some of the conditions under which it must operate. It must supply the desired mixture, at full load and at part load, over a wide range of speeds; it must provide for rapidly changing loads, such as occur during acceleration; it must operate satisfactorily in the cold days of winter and in the warm days of summer; it must perform suitably when the car is first started. In other words, it must operate under a widely varying set of conditions.

Now, as another illustration, suppose you had set before you for breakfast, dinner and supper on every day in the year an amount of food which would be all you required on that particular day in the year in which you were hungriest. The net result would be that there would be a great deal of food wasted throughout the course of the year. We have not quite that condition in the ordinary engine or with the ordinary equipment but we come sometimes dangerously near to it and I think possibly our greatest hope for saving of fuel is in getting as far away from it as we can. We must supply a ratio to meet the requirements of the engine under as many conditions as possible and to make the need for frequent adjustments as small as possible. At the present time, about all we ask the car operator to do is to make an adjustment when he starts up and about the only reason why he does not continue to operate with that adjustment is because the engine performs unsatisfactorily if he uses the starting mixture later in the operation. Unfortunately, or perhaps fortunately, you can use a very wasteful mixture at very little sacrifice in operation; so there is always the temptation, if you have the carburetor set for the worst condition of operation—that is, the condition where you have to supply the most fuel in order to get satisfactory operation—to let the adjustment remain permanent and waste fuel all over the rest of the range.

Developments to be Expected

The real development that I think we may look for, and it will not be at all spectacular, is a better knowledge of the needs of the engine over its entire range and better facilities for meeting these needs. A great deal has been done in that direction.

I will just mention one or two ways in which developments are coming about. At the present time, a good many carburetors take care of the full throttle condition by having some type of mechanism which operates so that, when the throttle is in its full open position, the orifice that controls the fuel supply is opened up somewhat more than when the throttle is in the normal position, furnishing perhaps a temporary excess of fuel but removing the temptation to supply such an excess all over the range, in order to get an adequate amount under full throttle conditions. Most carburetors also have some means provided whereby, when the throttle is suddenly opened to accelerate the motor, excess fuel is supplied temporarily to take care of that short period, until equilibrium conditions in the manifold and intake system are again restored. Practically all engines are provided with a special device for greatly increasing the fuel supplied during the starting period. In starting an engine on a cold winter morning, it may be necessary to provide more than ten times the normal amount of fuel in order that enough will be vaporized to give a combustible mixture.

These are some of the ways in which the carburetor and intake system designers are endeavoring to cope with the situation. Of course there are many others. For example, if we decrease the time required to bring the engine up to normal temperatures, we will decrease the time during which we will need to use abnormal mixtures. Much can be accomplished in this respect by supplying heat to the intake system. The demand is considerable in that direction, and in general, I think considerable progress has been made.

Quack Remedies

While on this subject, I think it would be worth while to mention what might be called quack remedies for saving gasoline. Some of these are offered in perfectly good faith and some I think are offered with full knowledge of their fraudulent character. In general these devices either themselves lean the mixture or else are claimed to possess some mysterious power which makes it possible for the car operator to lean the mixture and in that way obtain better economy.

The reason why such leaning is usually possible is because as I have pointed out, the tendency is always to use richer and richer mixtures until we reach such a stage that the car gives no trouble from too lean a mixture under any condition. The question may be raised whether, even if these devices when installed do no good in themselves, their sale is not justified, provided they directly or indirectly induce the operator to do something which improves fuel economy. If the improvement were permanent, I think that such sales might be justified but, in general, the user is interested in economy only temporarily. He installs the device, sees a slight gain and feels that the device is satisfactory. However, after he has used it for a time, some condition arises where the performance is not quite as good as he desires and he enriches the mixture, still believing that the device is improving his fuel economy. The net result is that, before very long, he is back to the original carburetor adjustment, tolerating the fuel waste in the complacent belief that he has done his best to prevent it.

There is another disagreeable side to the problem and that is, if you install a device of this character and think you have gotten an improvement, you believe then that the equipment, with which you originally were provided, must have been defective or, at least, not as good as it might have been and consequently you discredit what may be an excellent product of a reputable manufacturer.

One of the devices of this character, which is sold in a great many different forms, appears so often as to deserve special mention. This is the type which bleeds air, in one way or another, into the intake system. In this type of device, air is usually admitted to the manifold above the throttle, the rate of flow being controlled by a ball or spring operated valve. With the engine idling, the finger may be placed over the opening in the device, thus rendering it inoperative. Upon uncovering the opening, the engine ordinarily will speed up. This is a favorite method of demonstrating devices of this character.

It seems very conclusive. We have definite proof we have increased the power of the engine. We have added nothing but air and the one to whom the demonstration is made very readily believes the increase in power is due to some mysterious action of this device which results in either better vaporizing or better mixing of the charge in the manifold. What has really happened, of course, is that the demonstrator has simply increased the amount of charge, by opening what is equivalent to a throttle, and, at the same time, that has weakened the mixture by bringing in more air. The same result could have been accomplished, probably just as well, by leaning the mixture, by decreasing the needle valve opening in the carburetor, and then opening the throttle a little bit more.

The person who is mystified or convinced by the above procedure would see nothing whatsoever surprising in making two cups of coffee out of one, merely by adding a cup of water to the cup of coffee. It so happens that the amount of air which will flow in under these conditions is comparatively large because the throttle is nearly closed and the area of opening in this little device, in comparison with the area around the throttle, is appreciable. When we get to a full throttle opening, then the area in the device is very small in comparison with the total area of the intake pipe and the increase in the amount of the intake charge resulting from the use of this device is negligible. Hence, under the only condition under which an increase in power is significant, that increase in power is not obtained.

No doubt, a great many devices of this character are sold in perfectly good faith. Just what the philosophy or the code of ethics of the people who know better and yet continue to sell things of this sort is, I do not know. I suspect it is somewhat like that of the Arab chieftain whom you may recall. His son had encountered a young Englishman who, presumably, was an "easy mark" and the son, in discussing the matter with his father, asked for advice. Kipling makes the chieftain say, with reference to this "easy mark"—

> "If he, being young and unskillful,
> Gambles for silver and gold,
> Take his money, my son, praising Allah;
> The kid was ordained to be sold."

So much for the carburetor and intake system and the improvements we are likely to expect in that direction.

Another "Improvement"

Another minor source of improvement but one which, nevertheless, under certain conditions, may be appreciable, has been brought to the attention of a good many by certain advertisements claiming great increase in power from the use of a certain oil. In some instances, it is entirely possible that legitimate increases can be obtained in that way. The situation is best understood by first considering just exactly what the oil is supposed to do. The primary purpose of the oil, of course, is to keep the rubbing surfaces apart. In order to do that, it must have a certain viscosity, a certain body, and, if we decrease that, we decrease the ability it possesses to accomplish the desired end. Now, the oil must have sufficient viscosity to fulfill this purpose under the most severe conditions the engine is ever likely to encounter which means that, under most of the operating conditions, it probably is much more viscuous than is necessary. The sad part of this is that a large part of engine friction is due to fluid friction, the shearing by the piston of the oil film on the cylinder walls and this is proportional to the viscosity; the higher the viscosity of the oil, the greater the amount of friction. So that, so long as you use an oil of higher viscosity than necessary, you are wasting energy and that energy may be very appreciable under low load conditions, where the power of the engine is low in comparison with the friction. This friction loss may affect very materially the fuel economy of the car.

The only point to remember is, we must have some margin of safety and we must be sure that, when we get an increase in power by using thinner oil, we have not gone so far in that direction that, under extreme condition, wear may become abnormal.

A Promising Direction to Look

Probably the direction, in which we have been taught to look in recent years, for improvement in over-all economy, is that of compression ratio. As you all know, the compression ratio of an engine is the ratio between the volume above the piston when it is at lower center and the volume when it is at upper center. In the conventional engine, this compression ratio is the same as the expansion ratio and the efficiency of an engine depends upon the expansion ratio. The compression ratio is determined by the fuel, and developments in anti-knock fuels, the use of benzol blends and such possibilities hold out a hope for gain, through permitting an increase in this ratio.

Now the actual efficiency we would obtain, if the working fluid were air, which it is not, and if there were no heat loss to the jackets, which is not the case, and if the charge were completely burned at upper center, which is also not the case, is given by the expression:

$$E = 1 - \frac{1}{R^{n-1}}$$

in which E represents efficiency, R, expansion ratio and n, the ratio of specific heats, which for air, has a value of about 1.4. Now this, at first glance, because of the many "ifs" involved, seems like a very worthless formula. It nevertheless is of very real value for, while the average engine never attains the efficiencies shown by this formula, yet, when we change the compression ratio for an engine, the actual efficiency changes in exactly the same ratio as do these theoretical efficiencies which are never attained.

I do not remember the exact figures but, for a compression ratio of 3, this so called air cycle efficiency is in the neighborhood of 36%. For a compression ratio of 4, it is in the neighborhood of 43%. For 5, 48%; 6, 51% and 7, 54%. Tests have been made at the Bureau of Standards in which this ratio was carried up to the value of 14 to 1, giving compression pressures in the order of 400 pounds per square inch. The engine operated on the normal Otto cycle and the percentages gained in efficiency were exactly as would be expected from the foregoing formula. Now, such ratios are not going to be reached for a long time, for constructional and other reasons, but these tests show that present ratios do not even approach those that may ultimately be employed.

Increasing the compression ratio of the ordinary motor car engine, to the extent permitted by fuels that are available or likely to become available in the near future, might seem at first glance hardly worth while. The increase in performance however is greater than is indicated by the figures given above. These figures show the increase in the efficiency with which the fuel is burned in the cylinder. Now, changing the compression ratio does not change at all the amount of charge that enters the cylinder and hence if a change in compression ratio increases the energy obtainable from a unit weight of charge, it will also increase the power obtainable from a given size of engine. Therefore, if we have an engine and find we can use a higher compression ratio, then we will be able to decrease the engine size somewhat and still keep the same performance. When we decrease the engine size, we decrease the friction and, if the power output remains constant, then the mechanical efficiency is increased. A reduction in friction is particularly desirable at the part load conditions under which the motor car is operated for the greater percentage of the time. Under average driving conditions, the mechanical efficiency may be only about 50 per cent, whereas the engine, operated at full throttle, may have an efficiency in the neighborhood of 90 per cent. Recently, I had occasion to calculate roughly the probable increase in the average mileage per gallon of fuel that would result from increasing the compression ratio from 4½ to 6½, an increase entirely possible with the use of certain existing anti-knock fuels. The increase on this basis, that is, the increase in the thermal efficiency or the efficiency with which the fuel is burned in the cylinder, was in the neighborhood of 17 per cent but, when we figured the over-all increase which could be obtained, maintaining exactly the same performance with a very slight margin of improvement, we found that the increase was 27 per cent, which was decidedly worth while. The tendency, I think, will be for manufacturers, as fuels improve, to go too far—to use compression ratios a little too high. Consequently they will have troubles from pre-ignition and detonation and get thoroughly disgusted with the high ratio and will reduce it but not quite to where it was. The general trend therefore will be toward higher ratios.

In Conclusion

To return again to the camel, I presume that the chief reason why we know of the camel's ability to travel long distances on a given amount of liquid can be traced to the fact that, in the country in which he travels, liquid is scarce or high-priced. It is rather unfortunate that our interest in fuel consumption also seems to become aroused only when high prices or a serious shortage appears imminent. Such an attitude is perhaps a characteristic of the American people. At least "The Saturday Evening Post," which, if it is not the voice of the people at least is a voice heard by a great many people, breaks into rhyme and says:

"Madly, we squander the bounty and beauty around us,
Wasting, not using, the splendor and treasure of earth.
Only in grief, unavailing for glory departed,
Only in want, do we count what that treasure is worth."

If that is true, it is at least worthy of note that the condition is beginning to be recognized and recognition of a disease is usually the first step toward its cure. If the old definition of an engineer, namely, that "An engineer is one who can do with $1.00 what any fool can do with $2.00" is true, then we should surely be interested in, and appreciate as an engineering development, that car which can travel on one gallon of gasoline a distance which any old car can go on two.

DISCUSSION

HORACE C. PORTER: I should like to say a word in defense of, or rather in explanation of, the coal chapter in the American Petroleum Institute's report presented by the Committee of Eleven. Mr. Fieldner has referred to that chapter as stating that 525 billions of barrels of potential petroleum substitutes lay in our coal veins but giving nothing as to the rate at which these 525 billions could be produced. This, I think, is a perfectly fair criticism and such criticism has been made before. It is a defect in that chapter that nothing was said about the practicable rate, but the explanation is that the editors stipulated that the possible rate of production should not be gone into, and the author of the chapter was under limitations, therefore, as to his method of presentation. The figures given in that report were all for available supply—not rate of supply. The available resources of petroleum itself were given in the total supply available for years to come. In the same way it was stipulated that the coal figure should be given as the amount of petroleum substitutes available from the coal in the ground. Now it appears, of course, absurd to think of relying upon so high a figure as 525 billions of barrels of oil fom coal without considering the rate at which it can practically be produced. However, taking Mr. Fieldner's four points as to possible petroleum substitutes, it seems to me we do not want to get discouraged by the small amount of substitutes that can be obtained at a practical rate from coal by any one of those methods singly.

I believe the practical way to look at it is that, in the future when we have need of it, on account of the economic conditions and the rising price of petroleum, then we are going to utilize all four of these methods and perhaps more. We do not need to depend on any one of them alone. And although from coal carbonization, both high and low temperature, we may get by practical development only 13 per cent, as Mr. Fieldner says, I believe, of the total motor fuel supply, that is not an amount to be lightly regarded. It is an important item, especially if it is developed to that extent before petroleum itself has gone. And we have not yet reached the last word in coal carbonization. I believe that better methods will later be developed in low temperature carbonization. We are still in the infancy of this development. Probably we need not confine ourselves to a yield of six gallons of motor fuel per ton. It is easy to conceive of methods of treating the products of coal carbonization as they are evolved, so that they may be catalyzed or treated with hydrogen as they come off, and the large proportion of oxygenated bodies present in the primary products, converted to hydrocarbons, so as to produce perhaps ten or twelve gallons of motor fuel out of a ton of coal.

We are coming to big improvements along those lines and, as the price of petroleum from wells begins to be affected seriously by shortage, which, according to Mr. Hill's figures may not be soon, perhaps many years off yet, still when the price goes up, as it will some day, on account of shortage, then will come the time for the coal products to compete with it, and I believe it entirely possible that the rate of production may be such as to make this source a factor of importance.

B. B. BACHMAN: It seems as though the slogan which is evolved out of the three papers we have had tonight might be summarized in the desirability of making two blades of grass grow where one grew before. I am very glad Mr. Sparrow, in presenting the phase of utilization which he did, emphasized the general tendency to interpret conservation of fuel in automotive apparatus by means of reduction of operating ability. We see from time to time in the technical press, and possibly more frequently in abstracted articles in the public press, references made to results obtained in apparatus abroad, quotations made in a contracted form that would lead us to believe that these results are not merely a probability but an easily obtained possibility.

I was particularly impressed, in New York last week at the automobile show, with the evidence of one thing which has to my mind a significance on the immediate possibility of the acceptance of such procedure by the American public. I think it is safe to say that commercial opinion, as represented in products presented for sale, bears some relation to the demand and one of the newest productions placed before the American public, and on view at New York last week and Philadelphia this week, shows a motor which is probably in the neighborhood of 38 to 40 inches in over-all length and attached to it is a transmission which by comparison seems utterly inadequate. Now the lesson I would draw from that is this: That motor, in comparison with one which was considered a few years ago to be the most wonderful performing vehicle that had been produced, at a time when fuel and economy were less in the public mind than they are today, has practically the same cubical displacement. There has been no endeavor made whatever to capitalize advances in motor development to produce greater economy of operation. The vehicle itself is very much lighter than was the earlier vehicle I mention; the performance, therefore, should be, on the face of it, very much better. The commercial interests producing that vehicle feel that performance is the means by which they can attract the public attention, that ability for performance has made the presence of a change gear practically unnecessary for other than merely maneuvering and, in consequence, while motor size has increased, the transmission size has decreased.

I will grant you that developments in metallurgy have made possible higher stresses, bearing pressures and tooth loads than were possible in earlier days, but I understand a very good modern transmission, operated under conditions of full load, that is full motor load, has a useful life, in the laboratory, of possibly not over one hour and yet I do not think we are very much worried by transmission failures in our automobiles today. The lesson I would draw from this is simply that, as things are at the present time and as they probably will be for some time in the future, the American public, whether it is operating passenger cars, 'buses or trucks, will not consent to any reduction in operating ability. They demand acceleration and performance from the power standpoint on the open road, which can be obtained in no other way, with our present type of engine, than by a sacrifice of operating efficiency under the conditions existing the greater part of the time.

DR. J. B. HILL: I should like to ask Major Fieldner one or two questions in connection with the Bergius process: It has been my understanding that the conversion of the hydrogen in that process is rather small; that is, that there is considerable waste of hydrogen coming off. I should like to know whether that can be re-circulated. Then, in connection with Dr. Franz Fisher's synthol, I should like to know whether that product is blended with gasoline.

A. C. FIELDNER: Dr. Bergius states he can operate with hydrogen as low as 75 per cent. I presume he means he could re-circulate until his percentage of hydrogen was that low, if he started with pure hydrogen but there is considerable given off from the reaction so that a single pass may reduce the proportion of hydrogen to 75 per cent. I saw no evidence of any re-circulation in his experimental plant. I doubt whether one can count, in its present stage of development, on re-circulating hydrogen because of the rather considerable volume, some 10,000 cubic feet, of gas that is given off per ton of coal. I neglected to state that the large-scale retort he was using for cracking and hydrogenating petroleum is heated in a unique manner by the circulation of preheated nitrogen gas through the hollow wall of the steel retort. Heat is conserved by connecting a system of heat exchangers with the retort. Flue exchangers consist of coils of concentric pipes which are contained in heavy cast-iron towers, well insulated against heat loss. The inner pipe is perhaps ¼ inch in diameter and the outer one about 3 inches.

The raw oil entering the retort through the inner pipe is preheated by the hot nitrogen leaving the annular heating space of the retort. The retort consists of a double-walled steel cylinder about 30 inches in diameter and 25 feet long. The outer wall is 2½ inches thick and the inner wall about ¾ inch. The preheated nitrogen circulates in this annular space and heats the charge. The nitrogen, as it passes out of the retort, goes through the heat exchangers, preheats the incoming charge and, finally, when it is almost back to room temperature, goes through other heat exchangers where the nitrogen is heated again by the hot treated oil leaving the retort and is then heated to the required temperature by going through a lead bath heated in a producer-gas fired furnace. The nitrogen is maintained at a pressure slightly in excess of the pressure in the retort so as to prevent loss of hydrogen through the metal.

Fisher's synthol consists of 10 per cent of organic acids such as formic, acetic, propionic, and higher fatty acids, 30 per cent of water-soluble alcohols, aldehydes and ketones, 10 per cent of oils partly miscible with water, and 50 per cent not miscible with water. It blends with alcohol or benzol but Fisher gives no data on its miscibility with gasoline.

ROBERT W. A. BREWER: Similar discussions to this have been going on amongst engineers and other interested parties during the past twenty years and they have all been stimuated by the same thoughts, namely, the alarming increase in the price of fuel or the imminent shortage of fuel and, in the earlier part of this evening, we have heard figures which show us that the imminent shortage of fuel has not materialized. The alarming increase in the price of fuel has been met by another method of obtaining possible fuel from the crude. Now, during those twenty years, we have witnessed very little change in the number of miles per gallon of fuel obtained from an automobile and you may say to yourself, or to any of us who are engaged in tackling these problems: What have we been doing during these twenty years that we have made no progress? Well, we have been doing this: The chemists have shown us that the fuel has changed in character. They have met the fuel needs by obtaining more fuel which can be used in an engine designed to use that fuel. The engineers have been designing engines to use a different kind of fuel. And so they continue improving their design and meeting the fuel which is served to us to be used. And to my mind, with the present system of gasoline engine, that is the only thing we can do, for several fundamental reasons. We have done this satisfactorily and we are practically on a parity now with the mileage basis of twenty years ago.

If you look at the enormous number of automobiles on the street it must be very obvious to you who the fuel hog is and, if we can only catch the fuel hog and chain him, we are going to have considerable relief. Anybody who knows anything about certain cars or has tested them knows perfectly well it sometimes takes as much gasoline to turn round an engine and transmission as it does to drive the car along the street under ordinary usage and that is a condition which should not be countenanced. How we can take any action I fail to see right now but it seems that the oil companies are a very powerful group, the automobile industry is one of the most powerful groups in the whole world, and a combination of those two groups could have some influence upon the output of cars of low efficiency.

Let me just touch on one or two of the fundamental facts underlying the reasons why we cannot expect to obtain very much greater mileage from a real motor that is running under ordinary conditions of fairly reasonable mechanical efficiency. Mr. Sparrow told us something about compression ratios and how, scientifically, you can obtain greater output from a gallon of fuel by making changes in the mechanical design of the engine, but, of course, there are very well defined limits beyond which it is inadvisable to go. After all, a compression ratio of 6 to 1 is about all we can handle conveniently right now, Mr. Sparrow hinted, but did not forcibly put to you, one important factor; if you increase the compression ratio, you reduce the volume of inert gas added to the fresh charge every time and that is, of course, one of the basic reasons why you get more efficient usage from your fuel, because you are not diluting it to the extent that you were with the larger volume of inert gas. What happens is, of course, that you can run on a leaner mixture because there is not that dilution.

Mr. Sparrow also very briefly referred to the question of distribution. We have improved distribution enormously and the result is that in modern cars you get a reasonably high mileage per gallon. If you compare the fuel consumption of an individual cylinder, however, with the fuel consumption of an individual cylinder on the test bench, in which the manifold question does not come in, the fuel efficiency does not now vary very much; and the reason you get better mileage is because we understand distribution better and the whole number of the cylinders are more efficiently fed with the fuel.

The question of engine friction also has been touched upon and this is the final point I am going to make. We know that a motor turning around consumes a very large proportion of fuel for which we get no immediate results. We know that fuel is burned at an abnormally rapid rate when changes of speed and changes of power are required. The reason is that, when you have a fuel distribution system, you are continually changing the surface film of the inlet manifold and it is either lapped up or has to be replaced at very rapid intervals. Mr. Sparrow pointed out that most carburetors provide for this by an accelerating well. I may suggest that the wells are usually very much too small, if they are to work in the way they should work in a reasonably cool manifold, because they do not contain enough fuel to restore the surface film after the throttle has been momentarily closed; you are continually lapping up that surface film and the lapping up process is pure waste. If we could avoid that we should save fuel. There is one way to do this, namely by putting on an engine a transmission that will give an infinitely variable gear ratio and that, to my mind, is the only really hopeful method of increasing the fuel efficiency in the present type of automobile engine.

PROF. L. H. RITTENHOUSE: Mr. Sparrow mentioned possible economies by the use of higher pressures and proper lubricating oil. He raised the question as to what the present motor car could do and what it is doing today.

MR. SPARROW: I do not think that this is a matter that lends itself to calculation very readily. I think possibly Mr. Fieldner could give the best answer to it, if he wished, inasmuch as the work that the Bureau of Mines did at one time in analyzing the exhaust gases from a great many cars with reference to the ventilation of the Hudson River tunnel showed that the mixture the average car was using was much richer than would give best economy. I do not remember the exact figures. Wasn't it about 30 per cent richer?

MR. FIELDNER: Yes, it was about 70 per cent of what is possible.

MR. SPARROW: That is the figure I had in mind. But I should like to point out, in that connection, that I do not think we are justified in considering that as direct waste due to carelessness on the part of the operator but rather we should consider it as the goal of savings which may be made possible by changing carburetor design. The average man does not want to waste fuel. He wastes fuel because, in order to get the good performance he demands under certain conditions, he makes an adjustment that he forgets or that ordinarily is needed only for a very small portion of the operation range and, in that way, under all the other conditions of operation, fuel is wasted. In other words, what our designers must aim for is not so much to make good performance possible as to make poor performance impossible or, what is probably a better statement, to make good performance easier to obtain than poor performance.

V. L. SANDERSON: Does ethyl gas deserve the bad reputation it has been given?

MR. FIELDNER: Ethyl gasoline contains about 1 part in 1,300 of tetra-ethyl lead. Tetra-ethyl lead is an organic compound which, when mixed with certain other constituents such as ethylene bromide, is termed ethyl fluid and gasoline containing this fluid is called ethyl gasoline.

In November, 1923, at its Pittsburgh Experiment Station, the United States Bureau of Mines began a series of tests to determine the toxicity of exhaust gases from ethyl gasoline. This work was undertaken at the request of the General Motors Research Corporation and was made the subject of coöperative investigation. This occurred before ethyl gasoline was put on the market. The Bureau was interested in this problem, first, from the point of view of conservation of gasoline and, secondly, from the public health point of view, as to whether such exhaust gases imposed any hazard on the public health through the lead content of these exhaust gases. It is well known that there is a poison hazard in the lead industries and there was a possibility that the exhaust from ethyl gasoline might contain enough of the products of lead to be a public danger. These experiments were made in a rather practical way by connecting a small gasoline engine with a chamber of about 1,000 cubic feet capacity in which a constant circulation of a portion of this exhaust gas and air was maintained in such a ratio that it would introduce the maximum amount of exhaust gases that would just not cause poisoning from the carbon monoxide content of these gases. All exhaust gas contains carbon monoxide ranging from 2 to 12 per cent, the average being about 7 per cent. Carbon monoxide is poisonous and it is necessary to ventilate vehicular tunnels to such a point that the carbon monoxide will not exceed 0.04 per cent. The problem therefore was to introduce the corresponding amount of lead. That was done and these concentrations were maintained constant in this chamber by suitable control devices. In this chamber were placed a number of dogs, guinea pigs, rabbits, pigeons and monkeys. We started originally with dogs and guinea pigs, as recommended by the physiologists of our staff. A little later, we also retained several consulting physiologists from different universities, men who had specialized in lead poisoning. Each time we got a new consultant he wanted another type of animal in the chamber. We finally stopped getting more consultants because we feared they might suggest that we ourselves should go into the chamber. These tests were begun in November, 1923, and the first series of tests was concluded in July, 1924. The exposures were made for periods of 3 and 6 hours each day. We had two groups of animals; one group was exposed 3 hours and the other 6 hours a day. At the same time, several animals of each species served as controls and were never put in the chamber. All animals were examined by the pathologists and physiologists for symptoms of lead poisoning and, if for any reason any of the animals died, the carcasses were completely ashed and the percentage of lead in the ash was determined. Some of the animals, especially rabbits, died from diseases and infections. The dogs proved quite resistent to disease, and I think only one or two dogs died during the tests. It is interesting to record that we had three generations of dogs on test, two generations being born during tests; the third generation is still living and in good health. On the completion of the first series of tests, a preliminary report was published and, about this time, the cases of poisoning from "looney" gas occurred at Bayonne, New Jersey. These fatalities were caused by the vapor of pure tetra-ethyl lead which is a very concentrated and soluble form of lead that produces acute lead poisoning when inhaled or absorbed in the body, as will other soluble lead compounds taken in the same proportions. As will be remembered, these fatalities and the attendant newspaper notoriety brought the subject before the public at that time. The tests on exhaust gas by the Bureau of Mines were continued but additional tests, on the effect of the vapor, were started. We were at first concerned only with the effect of the exhaust gas. These accidents brought up the question of poisoning by the vapor form of tetra-ethyl lead when inhaled or absorbed through the skin, as well as the possibilities of sickness in employees of filling stations from absorption of the fluid itself or inhaling the vapors from the ethyl gasoline. In the first series of exhaust gas tests covering a period of 8 months, the animals showed no symptoms of poisoning and, on examining the animals killed at the end of the tests, no appreciable amounts of lead were found in their carcasses. In order to make the tests more severe in the second series, the concentration of tetra-ethyl lead in the gasoline was increased to 5 times the normal amount, the normal being 1 in 1,300. These tests were continued for another period of 8 months, ending July, 1925. There were no symptoms noticeable in the animals on test during that period and some of these animals had gone through the first series of 8 months. Some of the animals killed at the end of the period showed appreciable amounts of lead (just detectable by analytical methods), but the amounts were extraordinarily small and it has been found by other investigators that similar amounts of lead are found in cases where no special exposure to lead had occurred; so we can not say, from this second series of tests, that there was any positive evidence of lead poisoning in any of these animals. Likewise, similar results were obtained in the vapor inhalation tests of ethyl gasoline. As a matter of fact, the vapor from ethyl gasoline contains very little lead because of the low vapor pressure of this substance.

As you may know, in May, 1925, Dr. H. S. Cumming, Surgeon-General of the United States Public Health Service, called a conference to consider the public health hazard of leaded gasoline and appointed, as a result of this conference, a committee of 7 eminent physiologists to look into the question and make recommendations as to whether the use of lead containing gasoline was a public health hazard. They have reviewed the experimental work of the Bureau of Mines, as well as experimental work carried on at other institutions, and the experiments made by the General Motors company themselves. They have also been making observations of their own for 6 months and are submitting their report today (January 19) at a meeting in Washington. Perhaps we will find their report in the morning papers. At any rate it won't be long until we know what they think of ethyl gasoline—as a public hazard.

(Since these remarks were made, the report of the Surgeon-General's committee has been published. It is remarkably brief, about 4,500 words, but complete. The opinion handed in is that there are at present no good grounds for prohibiting the use of ethyl gasoline of the composition specified, as a motor fuel, provided its distribution and use are controlled by proper regulations, which should be adopted and enforced by the office of the Surgeon-General.)

DR. R. H. FERNALD: We have had three very unusual expositions tonight. We are to be congratulated on the presentations that have been made.

There are two or three points I should like to bring out. Mr. Hill, the first speaker, in his presentation showing the improved methods that are in vogue for getting gasoline and the improved methods now in use for securing the petroleum that is in the ground, carried the impression that the supply is essentially unlimited, at least I judge from the remarks of other speakers that they got the impression that the supply is not in immediate danger of exhaustion. It is difficult to get definite figures. I had occasion, however, to secure information from the Bureau of Mines within the past few days and I found the figures to be approximately these: For the least sanguine guesses the estimate is 40 barrels of petroleum in the ground per inhabitant—that is, per capita—in the United States. The most sanguine make it 200 barrels. We have apparently between 40 and 200 barrels per capita. The difference is actually but little, as shown by the following figures. In 1921 we were consuming petroleum at the rate of 3.8 barrels per capita. In 1925 we consumed at the rate of 6.6 barrels per capita. When you divide 40 by 6.6 you get six years approximately. When you divide 200 by 6.6 you get approximately 30 years; it makes little difference, therefore, which figures you use. The exhaustion of the supply is closely upon us, unless discoveries are made or some radical processes developed that will produce more from the wells than we now get. In other words, the exhaustion of the supply may not be tomorrow but it is not very many years away.

I was very much interested in Mr. Fieldner's presentation relating to possible petroleum substitutes and in his stressing over and over the one trend of thought—the processing of solid fuels by known or to-be-developed methods. We need not always use the same type of engine we have today nor use the same type of fuel. I think there have been some very distinct attempts made to produce engines of a different type from the standard automobile engine with the hope of greater efficiency in operation and resulting fuel economy. Although today we may not be able to produce, by process methods, enough liquid fuel fully to substitute for gasoline or even for any large proportion of the demand, at the same time the percentage we get is worth getting. I am further inclined to believe that the time is not distant when coal will be processed for many other purposes and our liquid fuel supply augmented through the general processing of solid fuels.

Regarding the question of automobile fuel consumption, what they can do and what they do do are two different things. Laboratory tests are one thing. Operating results are something quite different. The automobile on the test stand is different from the automobile on the road. An automobile operating under ordinary road and driving conditions cannot get daily laboratory attention; but it has to function even without such attention.

Very carefully kept records covering the performance for 50,000 miles for one seven-passenger touring car and 25,000 miles for a second one of the same make give very interesting results. I have learned, after ten years of study of records kept daily, that the performance on Monday has nothing to do with the performance on Tuesday—that there is no relation between the way the car eats gasoline on one day and the next, as ordinarily handled—just used. Gasoline consumption records for 100 miles tell nothing. For a 100-mile run some of you may get 17, 18 or 25 miles to a gallon of gasoline with your individual cars and that is the record you keep and talk about, but you know it does not hold true the next time you use the car. My gasoline record jumps all the way from 7 to 15 gallons per hundred miles, according to weather conditions, the amount of dirt in the strainer; carburetor setting, etc. A little dirt in the strainer will double the fuel consumption per mile right away.

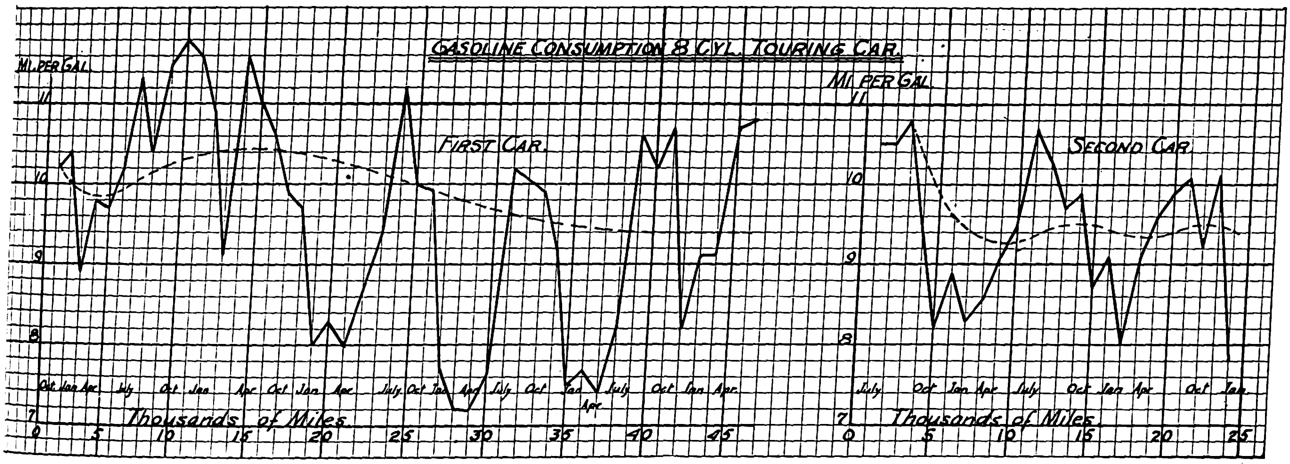

Figure 1

Variations in miles per gallon are so erratic that little definite information can be secured on the basis of 100 mile increments. Even on the basis of 1,000 mile increments, the variation is large as shown by the accompanying diagram. As indicated above, carburetor adjustment, dirt in the gasoline line and other factors cause considerable variation in gasoline consumption, but a study of Figure 1 will show that the major fluctuations are due to seasonal variations. In this figure, the miles per gallon shown by the heavy line are on the basis of 1,000 mile increments. The dashed line represents total mileage divided by total gasoline consumption or the average miles per gallon for any given number of 1,000 miles. For the first car, it will be noted this became practically constant after the car had been driven between 35,000 and 40,000 miles; that is, the variation per 1,000 miles was not great enough to materially affect the totals. The same is true for the second car.

It will be noted that, on the basis of the 1,000 mile increments, the mileage per gallon varied from 7.2 to 11.8, but that the average on the basis of 40,000 miles or more was 9.4. The seasonal variation is brought out more clearly in Figure 2 showing the average mileage per gallon of gasoline over a period of 8 years to be as follows:

For January and February	8.3
For March and April	9.0
For May and June	9.9
For July and August	10.6
For September and October	9.7
For November and December	8.9

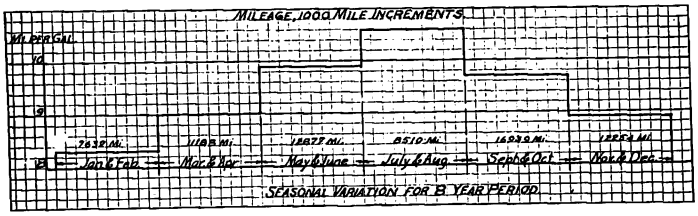

Figure 2

If, therefore, we could produce July and August conditions during the remainder of the year, our normal gasoline consumption with the average automobile would be greatly reduced.

One or two other points have been raised regarding gasoline consumption. I believe too much emphasis is put upon miles per gallon when purchasing a car.

Gasoline is the item that calls for the most frequent cash payment by the owner of a car and is naturally made the basis of argument by car salesmen. As a matter of fact, the difference in mileage between cars of the same class or grade amounts to practically nothing financially. This point will be brought out more clearly by the following figures:

The total cost of operating a seven-passenger touring car from October 1, 1916, to September 30, 1921, inclusive, was as follows:

Gasoline	$1,208
Oil, grease, etc.	126
Tires	900
Maintenance	1,609
Garage	817
Insurance	1,091
Depreciation	1,583
Interest on investment	450
Total	$7,784

or on the basis of cost in cents per mile for a mileage of 40,900, the figures are as follows:

	Cents
Gasoline	2.95
Oil, grease, etc.	0.31
Tires	2.20
Maintenance	3.93
Garage	2.00
Insurance	2.66
Depreciation	3.87
Interest on investment	1.10
Total	19.02

It will be noted that the operating expenses for this period, including the first four items, gasoline, oil, tires and maintenance, amount to 9.39 cents per mile, and that the fixed charges, including the last four items, garage, insurance, depreciation, interest, amount to 9.63 cents per mile or approximately a 50-50 division. If, therefore, gasoline represents an expenditure of approximately 3 cents out of 19 in the cost of operating a car, the saving by a difference of one or two miles per gallon amounts to very little in the annual operating expenses, that is, it may amount to $30 or $40 a year on a $1,500 or $1,800 expenditure.

Comfort and other features are, in my estimation, more important in deciding between two cars of the same grade than any slight difference in gasoline consumption that can exist.

Mr. Sanderson mentioned the low gasoline consumption per mile of European cars. I think an investigation will show that this is not due to greater efficiency but is due largely to the light weight of European cars. They are very small in comparison with the average American car and, if I mistake not, their engine capacity more nearly corresponds to the average demand than is true with our cars, thus making their load factor a much better one than we can hope to get. We desire flexibility of operation, speed and excess power and must, therefore, sacrifice in the way of economies.

MR. SPARROW: As far as bringing the warm weather conditions to the car the year round goes, I think everyone will appreciate that considerable is being done in that line, if they have seen the advertising and propaganda for Florida that has been going on recently. But that is not the only way in which that result is being brought about. In the last couple of years, I think a great deal has been done along the line of supplying additional heat to the intake manifold, so that the car warms up quickly, or of supplying additional heat to the air that goes into the carburetor, so that you are able to get satisfactory operation with the leaner mixture when the engine is cold and, therefore, can leave the mixture in that lean condition instead of enriching it to take care of cold weather conditions.

The points just made by Dr. Fernald are practically the complete explanation for the questions that Mr. Sanderson has raised. Cars in England do not actually give a great deal better mileage on the basis of ton miles per gallon than some American cars. They are very light; they have their petrol, which is very closely related to the gasoline that was available here in bygone days and not so far from what we have in use in aviation engines now. As they do not experience the troubles from cold weather, they are able to get by with lean mixture. A much greater percentage of the population owning cars getting high mileage and bragging about it is a condition that is common in England and one that tends to promote interest in fuel economy.

In the foreign cars, gear shifting is very frequent on a good many of them and they are contented with less performance and, for that reason, they get better economy than we do here. As the last speaker has just pointed out, the ratio of the cost of gasoline to your total car operating cost is about the same as the ratio the cost of matches bear to the cost of smoking. Nevertheless, when the time comes for you to experience that matchless misery of no matches, you will wish you had been a little more economical in the days when they were plentiful. If we realize that the production of gasoline involves a considerable amount of labor, as you surely must realize from what the other speakers have said, then it is clear the energy spent in refining gasoline is gone if that fuel is wasted, and there is no question that the public is glad to save it, if it does not involve any discomfort in so doing. That is what I was trying to express when I said the designers must make the obtaining of economy painless so that the operator can get it without doing anything different from what he does at the present time.

National Defence

A Conference Held December 15, 1925

Under the Auspices of the

Engineers Club of Philadelphia

(Continued from page 80, March issue)

Mobilization of the Nation's Man Power

By LIEUT. COL. WALTER H. JOHNSON

General Staff, U. S. Army

THE word "mobilization" is of comparatively recent use in the United States. The Century Dictionary defines it as follows:

"Mobilization. Military. The act of mobilizing or putting in readiness for service; the act of putting a body of troops on a war footing; as the mobilization of an army or a corps by mustering its members and organizing, equipping, and supplying it for active operations."

You will note the dictionary gives as an example of the mobilization of an Army Corps two things—1st the mustering of its members and secondly, organizing, equipping and supplying it for active operation. These are really distinct functions although mutually related, that is, we can't have troops without supplies and supplies are useless without troops to use them. There is a popular impression that mobilization merely refers to gathering large bodies of men together for service in time of war but this is only partly true, for these large bodies of men must be housed, clothed, fed, transported, equipped, and trained, with plans made to furnish the vast amount of supplies required by them and the armies in war.

This paper will not deal with the subject of supply and equipment to any great extent but only with the question of personnel, that is the officers and men, who would make up the armies formed to protect our country. As modern warfare is conducted on a scale so vast that practically the entire resources of the nation are used, it is necessary to consider the availability and possible use, of the entire manpower of the whole nation. Mobilization is merely a form of preparedness. Planning and preparing for mobilization in time of peace is one way of following the well known precept of Washington: "In time of peace, prepare for war."

Unpreparedness Policy

Unfortunately the United States never had, until after the World War began, a military policy based on preparedness. In fact, until the National Defense Act was passed, we can truthfully say we had no military policy, properly speaking, at all. We paid the price dearly, for this lack of preparedness and lack of a real military policy, in all our wars, the War of 1812, the Mexican War, the Civil War, the Spanish War, and finally the World War. They all cost an enormous and unnecessary amount of lives, money and time, due to our lack of preparedness.

The World, War, however, brought this matter of the cost and waste of unpreparedness home to our people and made us change the attitude of a century. Until then we maintained a small Regular Army, with no trained reserve, and relied in times of emergency upon the Organized Militia and on volunteer troops, organized, armed, equipped and trained *after the outbreak of war.* No provision was made for accumulation of war materials in quantity, nor for obtaining men and supplies immediately upon the outbreak of war. Under this system we only prepared for war after war was declared. The World War sharply emphasized the weakness of this system. Although the United States declared war April 6, 1917, it was not until six months later that the cantonments were ready to receive the drafted men to be trained and practically a whole year elapsed before we were turning out trained soldiers in quantity. Had not our allies been holding back the enemy, the delay could well have been fatal. And as for supplies, let me remind you we spent literally not millions, but billions of dollars, on such things as airplanes, artillery, ordnance and war equipment which practically never reached the front at all though the war lasted 18 months for us.

National Defence Act

The plain lesson of the World War was to provide a method that would enable the nation to put forward quickly and effectually its entire resources, both of men, and industry, to meet a national emergency. This is done in the very admirable National Defense Act, as amended in 1920, which gives us a real military policy. The general intent of the law was stated by the President in 1921 as follows:

"Our present national defense law establishes an economical and democratic military policy thoroughly consistent with our national traditions. It provides for a small Regular Army, to be augmented by great citizen forces in the event of national emergency. This is our traditional military policy. But whereas in the past these larger war forces have been extemporized after the occurrence of an emergency, the new law wisely provides that the framework of their organization shall be established and developed in time of peace, in so far as this is practicable, through the voluntary service of our patriotic young men. The Army of the United States as defined in the new law comprises the Regular Army, the National Guard, and the Organized Reserves. Every patriotic citizen should encourage the development of these forces, each within its proper sphere."

The National Defense Act provides the bare framework of the necessary defensive structure and that framework includes, as an important part, mobilization. That act provides that the basis for the organization of the peace establishment of the Army shall include all organizations

> "necessary to form the basis for a complete and immediate mobilization for the national defense in the event of a national emergency declared by Congress."

The act further charges the War Department General Staff with the duty to prepare plans for national defense

> "and for the mobilization of the manhood of the Nation and its material resources in an emergency, etc."

The law is clear. While the act specifically provides that supervision of plans for the mobilization of the "national resources" shall be directly under the Assistant Secretary of War, the War Department General Staff alone is charged with preparing plans for the mobilization of manpower. The question before us is what has the War Department done to carry out this mission?

Early Studies

Even before the National Defense Act became law, in June, 1920, the War Department had a Special Committee at work to consider the organization of the Army that would be required to carry into effect the provisions of the act. These studies enabled the War Department to adopt promptly, as the approved plan for reorganization, what is known as the Six Field Army Plan. This was approved by the Secretary of War, September 1, 1920, and is the basis for all studies and plans made since then, both for organization, operation, mobilization, training and supply. All this work is highly technical and very complex, requiring continuous study to perfect and improve. This policy is still new and must be adapted to meet our conditions.

No mobilization plans could be made until we first knew what was the objective sought, what was the ultimate plan of which mobilization was only a part, the "putting of a body of troops on a war footing." The "war footing" must be defined, otherwise we should be in the position advocated by the late

Mr. Bryan when he said no preparedness was necessary, as we could raise a million men between sunset and sunrise. Even if true, this means merely raising an unwieldy mob, without organization, arms, food or shelter—just a rabble.

Six Field Army Plan

The Six Field Army Plan gives us the basis for mobilization, as well as other, plans. The plan is largely based on our World War experience. It provides for a single Army of the United States, composed of all the forces going to make up that army—the Regular Army, the National Guard and the Organized Reserves—in varying proportions. These are, one Field Army of the Regular Army, two Field Armies of the National Guard, and three Field Armies of the Organized Reserves. This plan would give us, for the theatre of operations, an army of approximately 2,000,000 men made up of six field armies of 306,000 each.

But that is only part of the actual number of men required to place that fighting force at the front. We must add 20% more for the territory not included in the fighting zone. This territory includes training camps for troops to be sent to the front. Then we need another 15% for troops to cover the lines of communication, safeguard and forward the immense quantities of supplies of war material of all kinds consumed by modern warfare. Nor should we forget that our Harbor Defenses at home require protection and our Overseas Garrisons (Panama, Hawaii, the Philippines) need reinforcements in case of war.

All of the above items are an essential part of the Six Field Army Plan, which would bring the total number of troops of all kinds required, to approximately 3,500,000.

How were we to obtain this huge number of men? Would the Selective Service Law again be passed? Where would the recruits be assembled for examination and classification? How rapidly could they be clothed, equipped, trained? What reserve stocks of supplies were on hand? How fast could they be increased? Who would do the training? Where would the officers come from? These questions suggest a fraction only of the problems the War Department had to solve before provision could be made for "a complete and immediate mobilization for the national defense," as required by the law. A series of studies, conferences and reports was begun which, after four years' hard work, resulted in the adoption of the present mobilization plan in 1924. This is generally known as the War Department General Mobilization Plan, 1924, to distinguish it from earlier plans.

Some Preliminary Considerations

Before going in detail into the plan proper, your attention is invited to several determining factors.

In view of the satisfaction generally expressed during the World War, with the Selective Service Act, the War Department has assumed a similar law would provide the bulk of the troops. No "mobilization of the manhood of the nation" as specified in the National Defense Act could be effected without such a law. The volunteer system of recruiting is now recognized as unfair and, moreover, experience has shown the numbers produced are uncertain. Indeed the present trend of discussion would seem to favor an extension of the selective service system (in an emergency) rather than its abolition. As the United States has a huge supply of manpower it is immaterial (for this discussion) what would be the details of the system; suffice it that the number of men required could be secured.

The difficulty of recruiting with us would not, therefore, be so much in procuring the necessary numbers. The real trouble would rather be the Supply Rate, that is, how many men called to the colors can we properly look after? Early mobilization studies determined the Supply Rate as the dominant factor in time. It was no use to mobilize men faster than you could supply them with the great bulk of essential items.

In other words: "What will be required, how will it be obtained and how will it be preserved, moved and issued as needed?"

The total requirements consist of many thousand different items. It was found that, if they were computed only by an arithmetical process, using as a basis the tables of organization and tables of allowances, they included not only such articles as airplanes, guns, rifles, wagons, ammunition, etc., but, also, such items as thumb tacks, drawing instruments, rubber boots, etc. It was at once apparent that not all of these items had the same importance to military success. It was also plain that many of the items included articles, used in the daily life of the nation, which can be substituted and be used satisfactorily until such time as the production of the related military article can meet the military requirements after mobilization. There are items, however, such as rifles, field guns, ammunition, airplanes, etc., which constitute essential instruments of war. These may be termed the vital items.

A study of lists of the vital items of equipment and supply and a comparison of the production possibilities with requirements will show what should be maintained in storage as war reserves. Items for which substitutes may be used and all items, the lack of which will not have an important effect on the success of the mobilization or the military effort thereafter, can be excluded from the list of vital items. With large reserve stocks plus the procurement possibilities, the problem was not so difficult. As the reserve stocks became less the problem became more difficult, due to the fact that in time of peace there is an extremely low production (or no production at all) of some of the vital items and that for these, as will be mentioned later, there will be various periods of delay before production can overtake military requirements.

There are certain essentials to the mobilization and to military operations thereafter which cause no concern in study of the supply rate. For example, food or motor transportation. The total food requirements for the United States, including its army in peace or in war, will be but little more after mobilization than before, since total population to be fed is the same. The nation is more than self-supporting as to food, with the exception of a few articles which are not vital to the success of our military effort. The only preparation necessary is to arrange for the distribution. Of motor transportation there is more than sufficient. Existing vehicles, plus the potential production of existing factories, are far in excess of possible military requirements. On the other hand, there are certain items on the vital list which cause more concern such as rubber, natural nitrates, certain drugs, etc. In order to limit the annual expense, it is apparent that no large war reserves of these will be maintained and that, in calculations relative to the supply rate, the main reliance for these will have to be placed upon estimates as to possible procurement.

Organization and Training Rate

The third factor in determining the rate of mobilization is the organization and training rate. By this we mean the rate at which trained, partly trained or untrained manpower may be organized into appropriate units and trained for effective military employment. When the National Defense Act was passed in 1920, it contemplated the Regular Army would consist of 280,000 enlisted men, with proper complement of officers, and the National Guard was to reach its maximum strength, 435,000, by 1924. The entire framework of the Act was based on the theory there would be approximately some 700,000 men available as our first line of defense in case of emergency and a regular army of 280,000 men and 17,000 officers available for peacetime preparation and training of the civilian components in the Organized Reserves. It soon became apparent, however, that no such numbers would be available. By 1924, when the mobilization plan was adopted, reduced appropriations had cut the Regular Army down to a force of 12,000 officers and 125,000 men. The National Guard had 189,000 men with a set maximum of 250,000 as its goal. Thus not only were the actual numbers contemplated cut in two but in addition the demands made upon the Regular Army, to train the civilian components especially, were greatly increased.

All of these factors had to be kept in mind and coordinated, in preparing the final accepted plan which provides for the progressive mobilization of all factors. Each division of the General Staff was in closest touch in the evolution of the plans. An enormous amount of detailed work, covering several years, was necessary. The resultant mobilization plan may not satisfy the idealist. It is a merger of all these factors, a compromise adapted to the limitations of our national traditions and economic policies. But it is surprising what has been accomplished in spite of serious limitations. We will show you how great an advance in preparedness and national security are the results.

The Plan Itself

Turning now to the plan itself: Just what does the plan accomplish? How does it function? The General Mobilization Plan, 1924, is very involved, very technical, comprising in its entirety many bulky volumes of tables and thousands of detailed plans for the individual units. You are probably more interested in the results than the methods, so the plan itself will only be sketched roughly.

The United States is divided, for military purposes, into nine corps areas, each one having approximately the same manpower, though naturally of varying size. The mobilization plans contemplate decentralization so that the details of the work will be carried out by the Commanding Generals of these nine corps areas. It is obvious that mobilization in the last analysis is a local matter, that is, the assembling of men near their homes. The objective of any mobilization plan is the bringing together of the largest numbers of men possible in the shortest period of time in an orderly manner, to be made available for the Army.

The scheme itself is simple. First we have a Basic Plan which embraces the entire country, specifies the forces to be provided, the methods to secure, organize, train and supply these forces and assigns to those who are to do the work their specific missions, or jobs. Certain essential details must be worked out by the War Department itself before the decentralization desired can be effected. This is done by having each division in the General Staff prepare what is called an Appendix. These establish in detail the policies and instructions to be given the development and execution of the basic plan. There are four appendices covering the procurement, organization, operation, training, mobilization and supply of the forces to be mobilized. The persons charged with the actual execution of the plan, that is, the commanders of corps areas in the United States and departments outside of the United States as well as chiefs of branches such as Infantry, Artillery, etc., prepare outlines of what they consider necessary to execute the mission assigned them under the foregoing basic plan and appendices. These are called annexes and give not only their mission but also a synopsis, usually in tabular form, of the detailed plan.

Unit Plans

We now come to the most detailed part of the General Mobilization Plans, the preparation of Unit Plans. A "unit" is a body of troops. Its size is determined by the established tables of organization. Mobilization plans call for the organization of many thousands of units, each varying in size and locality. Unit plans are prepared under the direction of Corps Area Commanders, chiefly, and also of the Chiefs of Branches and must be thoroughly coordinated with the plans as a whole. Each unit plan must be prepared so that the mission, organization, training, personnel, intelligence, supplies, shelter, hospitalization and sanitation features will be fully covered, in order that the officials of the unit, and the next higher commander, will have full knowledge of the unit and its part in the military activities on and after Mobilization Day. An important detail is the place where the units should gather, where their headquarters should be located. This is largely a local matter but controlled also by military considerations, hence the law provides these allocations should be made by boards of officers composed jointly of Reserve Officers and Regular Army officers. These joint boards also designate the name and number of the units, since the law seeks to perpetuate the traditions of the divisions and other units taking part in the World War. For example, the old Yankee Division from New England, the 26th, is a unit in the present plans from the same territory.

The plans contemplate our Regular Army being mobilized within 5 days after M day and the National Guard in 15. These two would increase their present numbers by active recruiting of volunteers until the selective service men came in. These two forces would be the first to organize on a large scale while plans were being pushed to get the Organized Reserves ready in quantity. The R. A. and N. G. form almost the whole force of the First Phase which contemplates furnishing 1,300,000 troops within four months after M Day. These include 3 Field Armies with harbor defense, overseas and other necessary troops.

The Second Phase units are from the Organized Reserves. They are mobilized by stages, beginning with the fifth month and ending with the twelfth month. They would furnish three complete Field Armies (in addition to the three Field Armies organized in the First Phase by the Regular Army and National Guard) together with various extra army and corps units, headquarter troops and replacements. The total number of these armies and other troops is approximately 3,500,000. The importance of the Regular Army is far more than its size would seem to indicate. Upon this small Regular Army falls the responsibility not only of organizing and training the units in peace time to make possible these huge expansions of citizen armies in war time, but also, following World War methods, of leavening the entire mass with a small number of Regular Army officers.

In passing, your attention should be called to the fact that these plans provide for the organization of a large number of installations such as Reception Centers for recruits, Replacement Centers to train men, training camps and schools, mobilization points, internment enclosures, supply points, ports of embarkation, General and Station Hospitals, etc. The ramifications of any plans calling for the organization of millions of men, are literally endless.

Comparative Results World War

You will be interested in comparing the numbers of men that will be produced under the present mobilization plans in a future emergency with those actually sent overseas in the World War. During the World War, the best efforts of this nation delivered into the theatre of operations 2,000,000 odd members of the Army during a period of *eighteen months*. As against this rate of 1917, the present plans will enable us to have ready for any theatre of operation in *eleven months* as many men, in the form of trained and balanced forces adequately supplied, as were delivered for that purpose during the World war in eighteen months. A detailed comparison by months is even more illuminating. The following figures show by months the numbers sent overseas during the World War in comparison with those available under the present mobilization plans:

Sent Overseas		Present Mobilization Plans	
1st month	1,700	1st month	300,000
2nd month	14,000	2nd month	550,000
3rd month	27,000	3rd month	825,000
4th month	45,000	4th month	875,000
5th month	79,000	5th month	975,000
6th month	122,000	6th month	1,000,000

The significance of these figures is not so much in the large numbers produced at the end of a year as in the extraordinary increase in the numbers made available in the early months of the emergency.

You will say, "This is all very fine, but how does it actually work?" That, of course, we cannot answer definitely. A complete solution of the problem is a task of many years, especially the industrial portion but, with the basis herein referrred to—the cornerstone—as a constant in its main factors, steady progress toward the complete solution of the problem is possible. The details essential are not yet worked out, by any means, but every month sees progress made and changes that strengthen the weaker parts. Progress and perfection of mobilization plans is largely a matter of education, with the War Department, as the directing head, exerting a steady pressure.

NEW BOOKS

BOOK REVIEWS

A Treatise on the Law of Surveying and Boundaries—By Frank Emerson Clark, of the Minnesota Bar. xxxvii. + 631 pp. 4½x7½. Flexible leatherette, $5.00. 1922.

Quotation from preface: "The underlying idea of this work had its birth in the necessity for such a help that the author discovered in a somewhat extended experience as a public and private surveyor and later as a practising lawyer often called upon to investigate land titles. So far as the author is informed no similar work has heretofore been published." The necessity referred to certainly exists and is well met by the present book. A very complete table of contents; a valuable table of cases and an unusually complete index add to its serviceability.

Charts and Graphs, an Introduction to Graphic Methods in the Control and Analysis of Statistics—Karl G. Karsten, B. A. (Oxon). Introduction by Carl Snyder, Chief Statistician of the Federal Reserve Bank of New York. xl. + 724 pp. 6x9. Flexible leatherette, $6.00. Well indexed.

While this book is modestly styled an introduction to the subject, it appears to lack little, requisite for a very thorough knowledge or for skillful handling of these aids to analysis and exposition, that the engineer and statistician will want in the greater part of their work. The writer of the introduction, very justifiably, refers to it as "an encyclopedic and exhaustive work." It would be difficult to think of any branch of the art—the author's taste and skill make it clear that it is an art as well as a science—that has not been given adequate, though, perhaps, brief, mention. The book is further ornamented by the writer's scholarly style, brightened by not a little humor where good taste permits.

Labor Attitudes and Problems—By Willard E. Atkins, A. M., J. D., Associate Professor of Economics, University of North Carolina, co-author of "The Worker in Modern Economic Society"; and Harold D. Lasswell, Department of Political Science, University of Chicago. xiii. + 520 pp. 5½x9. Cloth, $5.00.

"The purpose of this book is to present to students who have already obtained some slight background in the concepts and terminology of economics, a more intimate consideration of the worker in society . . . The book is addressed primarily to students of the junior college," from the preface. It is, however, a most useful book for the engineer that has had his interest directed toward economic questions and particularly toward those bearing on the efficiency of labor.

Depreciation in Public Utilities, Relation of Accrued Depreciation to annual Depreciation and Maintenance—By Delos F. Wilcox. 112 pages, 5½x9. $2.00 Board. 1925.

This is the second monograph in the series which is being published by the National Municipal League. Dr. Wilcox has presented in this monograph the theory and application of accrued depreciation as particularly related to street railways. He has shown why he thinks this method of treating depreciation in public utilities is preferable to other methods. To substantiate his position, he has summarized the experience of a number of municipal railway systems.

Popular Research Narratives—Volume II, Fifty Brief Stories of Research, Invention or Discovery, Directly from the "Men Who Did It," pithily told in Language for Laymen, Young and Old, Collected by the Engineering Foundation. viii 174 pages, 4½x7. Cloth. $1.00.

Fascinating as any book of short stories while, at the same time, serving as authoritative announcements of discoveries, inventions and applications that are far in the van of our scientific, engineering and industrial progress. It is impossible to give a synopsis of the contents which seem to exclude nothing within the range of the practical advancement of human knowledge and its application. No would-be well-informed person dare ignore these books, the compilation of which constitutes not the least of the raisons d'etre of the Foundation.

The Things That Are Caesar's—By Guy Harrison Walker. $2.00.

A defense of wealth, neither written nor published for profit, but solely to stimulate sound economic thinking to protect the future of capital and labor. Logical, clearly written, it cannot fail to clarify existing ideas of what wealth is, how it is created, why it is justified and why it is essential to the further improvement of the welfare of the human race.

Coal Tar Distillation and Working Up of Tar Products—By Arthur R. Warnes, A. Inst. E., M. I. Chem., E. C. I. Mech. E., F. C. S. Third Edition rewritten and greatly enlarged. 550 pages, 151 illustrations and many figures. 45s. London.

A useful work for one desiring to have a knowledge of the fundamental principles involved and of the main directions in which progress has been made.

ENGINEERS & ENGINEERING

MAY, 1926

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The Business Situation

WE find a word of caution in the reports of many of the larger industries and in the publications of most of the large financial institutions. In the last Business Bulletin of the Cleveland Trust Company we read:

"There is but scant validity in the frequently asserted claims that a serious reverse in the security markets need have no harmful implications for trade and industry, and still less in the assertion that the decline in stock prices will have a stabilizing effect on general business. The fact is that business sentiment is better, and constructive initiative is more courageously exercised, when security prices are moving up than when they are declining.

"Coincidently with the great decline in stock prices there has come a recession in the phenomenal real estate boom in Florida, and reports are beginning to appear of a similar slowing down in the minor real estate booms that have been under way in the suburban sections of many of the large cities. Failures have been a little more numerous than last year, and wholesale commodity prices, in continuing to decline, have constituted the one really serious weak spot in the general situation.* The evidence begins to indicate that industry has been holding up better than wholesale and retail trade, and it may be that production is beginning to run somewhat ahead of consumption.

"The slowing down of speculation in securities and in real estate has given a more sober tone to general business. Industry is very active, employment is good, agricultural prospects are promising, and trade is better than fair. In general it may be said that business during the first quarter has been good in most lines, and that it begins the second quarter at a pace that is distinctly moderated from the high speed of the closing months of 1925, but which is, nevertheless, fairly satisfactory.

"The output of automobile passenger cars and trucks during the first two months of the year was not exceptionally large, but the March production was so great as to bring the total for the first three months to larger figures than those for the first quarter of any previous year. Most of the cars made during the past two months have already been sold to dealers, but a large proportion of them have not as yet been bought by individual users. Retail sales during May and June are large, and those of the second quarter of the year are much greater than they are during any other quarter. April will determine whether the automobile companies can continue to manufacture cars at any such tremendous rate as that of March, or whether they must moderate their scale of activity."

In Iron and Steel, signs of contraction have appeared for one or two products, average prices are lower, and sentiment in the trade itself is growing less confident of prolonged continuation of present activities.

At the close of March 235 furnaces were in blast compared with 232 one month before. With 377 furnaces now listed as available for use, the percentage of furnace activity at the close of March was 62.4 per cent against 60 per cent one year before, and a theoretical normal of 60 per cent.

During the past four years a great nation-wide building boom has been under way, and it seems entirely probable that it must soon begin to subside somewhat if it has not already begun to do so. When the volume of building construction moves to lower levels it is sure that the number of real estate conveyances will decline also. One result of this will be a restriction in the flow of real estate mortgages and real estate bonds available for purchase by investors. The volume of such instruments and securities purchased during the past few years has been enormous, and any sharp reduction in the supply will have important effects in the investment markets.

As Byron W. Holt, of Goodbody & Co., sees the situation: "Earnings statements for the first quarter reflect the satisfactory business conditions which existed during that period and which still exist. The retail dry goods trade seems to have carried most of the trade depression to date because of the late Spring. There is little reason to believe that operations in any line for the next few weeks will show much decline and it may be expected, therefore, that general earnings for the current quarter will be about as satisfactory as they were in the first three months of the year. The rate of production of iron and steel exceeds new orders, but the same condition existed from February to August in 1925. Building operations as reflected in new permits have not yet begun to show the decline predicted for them. Mail order and chain store sales, car loadings and bank clearings continue at a high level. Commodity prices for the last two weeks, according to Fisher's Index and the Times' Analyst, have advanced after eight successive weeks of decline. Of course the upward trend here is in part due to strength in cereals which may be partly on account of the technical condition of the speculative markets. Anyhow there is no reason for anticipating an immediate period of business depression which would affect earnings to the extent of endangering dividends on good investment stocks."

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*See diagram April issue ENGINEERS AND ENGINEERING, page 89.

Optimism on business that was so evident early in the year seems to have lessened somewhat, as current trade still fails to measure up to the volume of this time a year ago, according to R. G. Dun & Co.'s weekly trade review. This is attributed to unseasonable weather, although it is believed conditions will become stabilized as the season advances.

Manufacturing is subsiding somewhat from the high level that marked its activity during the first quarter.

To the Guaranty Trust Company of New York, "it appears that business has entered a period of readjustment similar in many respects to the downward movements which occurred in the spring months of 1924 and 1925.

"So far the declines in stock and commodity prices have been somewhat more pronounced than those of a year and two years ago, while the recession of general business activity has apparently been less. In recent weeks the movement of stock prices, while irregular, has given no sign of renewal of last month's marked weakness. Commodity prices, on the other hand, have continued to decline rather sharply—an interesting development in view of the opinion expressed by some observers of the economic situation that the decline is due to international influences, and that it will probably continue until the price level of the United States is in closer adjustment with those of other countries than it has been in recent years. The plausibility of this view is certainly enhanced by the unmistakable tendency toward import balances in our foreign trade—not only in the last few months, but increasingly with the gradual disappearance of the abnormal situation occasioned by the war.

"Present conditions warrant the belief that the business recession will be moderate and that it will not extend over a long period. Despite the high level of industrial activity that has obtained since last summer, the situation in most of the commodity markets is essentially sound. While the readjustment in some industries may be rather sharp, there is little ground for anticipating the advent of general depression. The probability is rather that the trend will be similar to that of the last two years, with a short down-swing followed by quick recovery. One of the most important factors bearing on the near-term outlook is the distinct ease in money rates—a condition that rarely accompanies a major downward movement in business activity. In view of the fact that business conditions in coming months will be profoundly affected by the purchasing power represented by the great cash crops, the exceptionally good condition of winter wheat is most encouraging."

It so happens that 1926 to date has brought many new achievements that had not been expected, and a recession from these peaks later in the year would be regarded as natural. In their present mood, the authorities will be slow to cry "wolf" again unless better evidences of depression appear than a break in the stock market.

As we enter the fifth month of the year, we find the optimists somewhat less optimistic over the distant future than they were at the time they made their yearly forecasts, and the pessimists less pessimistic. It is difficult nowadays to find any responsible authority that will predict a pronounced upturn in the prosperity curve, or any who expect bad times, but on every hand may be heard expressions that reflect the expectation of continued good business generally.

Recent foreign trade returns disclose for several months an excess of merchandise imports over merchandise exports. The aggregate excess for the first quarter of this year was $125,000,000. This compares with an export surplus of $206,000,000 during the first three months of 1925. Great Britain takes about 21% of our total exports.

The economic and political aspect of Great Britain is such, that at the present writing it is difficult to predict the effect upon American business of the ultimate solution of British labor troubles. From the standpoint of the possible political outcome, the situation is serious for us. Should labor be successful, through the means of a general strike, in enforcing its demands, the situation throughout the world will become more serious than it has ever been. The present government must fight not only to avoid the present attempt of labor to dominate the situation, but also to regain the ground lost through subsidizing the coal industry and granting the dole.

Items of Interest

Earnings of Graduate Mechanical Engineers

The average earned income of graduates of the Mechanical Engineering Department of the University of Pennsylvania during their first year after graduation is $1,800. The fifth year after graduation, the average is $3,000, and the tenth year, $5,950.

Dr. R. H. Fernald, Director of the Mechanical Engineering Department of the University's Towne Scientific School, compiled the statistics from the replies to a questionnaire in which the graduates were asked to record only straight salaries or earned incomes.

All the Department graduates of the Classes of 1913 to 1924 inclusive, whose addresses were known to the Department, received the questionnaire, and 220, or eighty-six per cent replied.

The survey shows that not a single graduate met with phenomenal financial success in the engineering profession in a short time, but virtually every man recorded steady progress as reflected by salary increases, except during the period of depression following the World War when the salaries of the majority either remained stationary or dropped slightly.

As compared with the Class of 1913, members of the Class of 1924 earned more than twice as much during their first year following graduation, a circumstance undoubtedly accounted for principally by the relative values of the dollar for the dates named.

A brief summary of the salaries received by the graduates during their fifth year after graduation is as follows: Two per cent received $5,000 to $6,000; six per cent, $4,000 to $5,000; thirty-two per cent, $3,000 to $4,000; forty-four per cent, $2,000 to $3,000, and sixteen per cent, $1,000 to $2,000.

The tenth year after graduation, eleven per cent of the members of the Classes of 1913, 1914 and 1915, were receiving salaries ranging from $10,000 to $13,000; seven per cent, from $7,000 to $8,000; two per cent, $6,000 to $7,000; thirteen per cent, $5,000 to $6,000; eleven per cent, $4,000 to $5,000; thirty-eight per cent, $3,000 to $4,000, and eighteen per cent $2,000 to $3,000.

Of the eighty-three men who reported from the Classes of 1913 to 1917, all of whom have been out of college at least eight years, forty-one per cent now are receiving $5,000 a year or more; twenty per cent are receiving $7,000 or over, and ten per cent are receiving $10,000 or over.

In commenting on the survey for the benefit of students in his Department, Dr. Fernald said that while he considered "salary curves" decidedly interesting, he did not believe they alone indicated the value of university-trained men.

"It is generally agreed that education, intelligently applied, increases a man's earning capacity, but that is not its primary object," Dr. Fernald told the students. "Higher education equips a man for far greater service to the community than any which can be measured in terms of dollars and cents.

"Men like you who are enjoying the privileges of higher education owe the world something when you leave the University. Your 'salary curve' shows what you are getting. That is important. But watch the 'service curve' which shows what you are contributing to the betterment of your profession and the world in general. That's the real measure of your worth."

CARNEGIE INSTITUTE OF TECHNOLOGY

Research Fellowships

An extensive program of mining and metallurgical research is planned at the Carnegie Institute of Technology in cooperation with the U. S. Bureau of Mines and eight research fellowships will be available in connection with the program for next year. These fellowships are open to the graduates of colleges, universities, and technical schools who are properly qualified to undertake research investigations, and will be awarded for a ten months' period beginning August 16, 1926.

Each fellowship carries a stipend of $750. Holders will be registered as graduate students and as candidates for the degree of Master of Science, unless an equivalent degree has previously been earned. Applications should be made to the Secretary, Mining and Metallurgical Advisory Boards, Carnegie Institute of Technology, Pittsburgh. Pa.

NATIONAL INDUSTRIAL CONFERENCE BOARD, INC.

Gain in Population Through Immigration

Under the 2 per cent quota act of 1924, this gain continues at a decreasing rate, according to immigration statistics for the first seven months of the second year under the operation of the new law. But the trends in migration noticeable during the first year under the new law, while continuing in the second year, show a number of interesting changes. The net loss in common labor repeated itself, but was cut by more than half. Alien skilled labor came and went in slightly larger numbers during the 1925-26 period than in the same period of the preceding year, and shows a slight gain in "net immigration." Obviously, we are gaining skilled labor and losing unskilled labor. Net immigration of farm laborers also showed a slight gain, while the influx of independent farmers was reduced considerably.

The bulk of immigration under the new quota restriction law continues to come from Canada and Mexico, although the gain from Canadian immigration in the seven months period of 1925-26 was about 20 per cent less than during the corresponding period of 1924-25. Mexican net immigration, on the other hand, showed an increase of about 4 per cent over the 1924-25 period. Great Britain, although more than half of the year has passed, thus far has filled less than one-third of her quota. Scandinavia as a whole is in a similar position, while the Irish Free State also lags behind. Notable is the change in the migration of Italian aliens to and from this country, who now seem to come in larger and return in smaller numbers than they did during the first fiscal year under the new quota act.

A Warning Against Neglecting Agricultural Development

Danger lurks in an unbalanced economic development and American industrialists must consider the agricultural problem from the viewpoint of national economy in order to avert serious consequences to our whole economic structure. The shrinkage of our agricultural "plant" in proportion to our population growth and the dwindling of agricultural wealth and income since 1900, are real symptoms of a relative decline in American agriculture which challenge the attention of all classes, including that of the urban manufacturing and commercial population, for reasons of self-interest if no other.

Other nations have, since the war, taken cognizance of the necessity of an agricultural development that well balances the requirements of their population growth and have been making special efforts to increase their agricultural production and to diminish their dependence on outside sources. As a result, wheat production in Australia has increased 110 percent from 1919 to 1925; in Canada, during the same period, 100 per cent; in France, 75 per cent; in Italy, 42 per cent; in Argentina, 25 per cent, and in India, 15 per cent. Despite these efforts, there is indication that the total world production, also, of agriculture is not keeping step with the population but is actually declining. Figures on agricultural world production show an actual net decrease in most important farm products.

This situation of reduced agricultural production the world over indicates a world agricultural problem similar to what exists in the United States, and is an added reason why prompt attention should be given this national problem. Neglect of the farmer's difficulties of high cost production with low prices in the markets where he must sell, may lead ultimately to a reversal of the problem. It might result in conditions where the non-farming industrial groups, constituting the urban population, would face the dilemma of having to produce at rising costs, caused by the rising prices of scarcer food and, on the other hand, of having to sell their manufactured goods at low prices in ever sharpening competition with the world.

U. S. DEPARTMENT OF AGRICULTURE

New Dust-Handling Equipment for Grain Elevators

Improved dust-handling machinery has been designed by the Bureau of Chemistry for installation in grain elevators for the prevention of dust explosions. In Bulletin No. 1373, just issued by the Department, the mechanical methods of controlling dust conditions have been divided into dust collection and dust removal. Dust collection deals with the methods of removing dust clouds at their source by means of induced air currents, supplied through ducts connected to a fan system. Dust removal deals with the methods of removing static dust, that is, dust that has settled on the floors, walls, and equipment. Ventilation has been divided into natural and mechanical ventilation.

Detailed drawings representing every phase of the equipment and manner of installing at all points where dust is collected are included in the bulletin, making it a valuable guide to plant managers. Dust collection in grain elevators may not entirely prevent explosions, but it will keep a small dust ignition from developing into a disastrous explosion. Furthermore, dusty atmospheres may affect the health of the workmen. More efficient work can be done in a clean, orderly, and well-run plant than in one where dust clouds are permitted to form. Aside from reducing the dust-explosion hazard, then, the installation of dust-collecting equipment improves the health and efficiency of the workmen.

A copy of the bulletin may be obtained by writing to the Department at Washington, D. C.

More Than a Billion Dollars for Rural Roads in 1926

Highway construction and maintenance in 1926 will equal and possibly exceed the progress made in any other year, according to estimates from the various States compiled by the Bureau of Public Roads.

A total of $1,030,286,948 is available for the construction and maintenance of all rural roads. Fifty-eight per cent or $598,590,948 is to be available to the State highway departments, of which $461,515,400 is for construction and $137,075,548 for maintenance. These funds will provide for the construction of 6,751 miles of asphalt, concrete and brick paving, 14,320 miles of sand-clay, gravel and macadam and 8,145 miles of improved earth road. The States also plan to maintain 234,582 miles of road.

The total expenditure by counties and local units for both maintenance and construction is estimated at $431,696,000, which is less than the similar estimate made one year ago by about $31,000,000. This reduction is more than offset however by the increase of more than $58,000,000 in funds estimated as available to the State highway departments. For a number of years there has been a trend toward placing control of all important State roads in the hands of the State highway departments.

A Motor Car for Every 5.8 Persons in U. S.

More than twenty million motor vehicles were in use on the highways of the United States in 1925, according to the Bureau of Public Roads. The total registration reported was 19,954,347, but there were in addition 96,929 State and Federal government-owned vehicles not included in this figure. The increase in registrations during the year amounted to 2,360,670 or 13.4 per cent. Truck registration increased 14.5 per cent for the entire country. New York leads in total registration with 1,625,583 followed by California, Ohio, Pennsylvania and Illinois in the order named, all with registrations of over a million.

There is now one motor vehicle for each 5.8 persons in the United States. California has only 2.9 persons for each motor vehicle, while Iowa has 3.6, Nevada 3.7, Kansas 4.0 and Oregon 4.0. At the other end of the list is Alabama with 12.0 persons per vehicle, but ranking among the highest in increase during the year.

Stale Chlorinated Lime Ineffective as Germicide

Chlorinated lime, also known as "bleaching powder," and sometimes incorrectly called "chloride of lime," a substance used extensively as a germicide, deodorant, and bleaching agent, loses its strength with age, eventually becoming ineffective as a germicide. An investigation has been made by the Department for the purpose of determining the rate of this deterioration and the results of the study have been published in Department Bulletin 1389, entitled "Deterioration of Commercially Packed Chlorinated Lime." A copy of the bulletin, which gives many details relative to the investigation, may be obtained free from the Department.

DEPARTMENT OF COMMERCE
WASHINGTON

The Results of Analyses of Numerous Virginia Coals

The coal production of Virginia in 1925 amounted to approximately 12,455,000 tons. The coal-producing counties of the State are well served by railroad transportation lines. The coal is widely distributed. A considerable tonnage is shipped by water from Norfolk to New York and to New England ports. The higher grades from the Southwest fields of the State have an enviable reputation as steam fuel. The great pressure to which the coal has been subjected has changed it at many places from bituminous to semi-bituminous, and in a few places to semi-anthracite.

Technical Paper 365 is the seventh in a series prepared by the Bureau of Mines containing information in regard to the characteristics of the coals mined in the different states. Previously issued papers in this series relate to the coals of Kentucky, Ohio, Utah, Alabama, Iowa and Pennsylvania, the last-named being published by the Pennsylvania State Topographic and Geologic Survey, Harrisburg, Pa. Copies of Bureau of Mines Technical Paper 365, "Analyses of Virginia Coals," may be purchased from the Superintendent of Documents, Washington, D. C., at a price of 10 cents.

Explosion Hazards From the Use of Pulverized Coal

An investigation of these has been made by the Bureau of Mines. When pulverized-coal fuel in the industrial plants of the United States has caused fires and explosions that killed workers and damaged property, the Bureau of Mines availed itself of the opportunity to study the conditions under which such disasters occurred, and thereby collected information complementing investigations of dust explosions in coal mines.

Detailed safety instructions are given in Bulletin 242, "Explosion Hazards from the Use of Pulverized Coal at Industrial Plants," by L. D. Tracy, coal mining engineer, copies of which may be obtained from the Bureau of Mines.

Methods for Sampling and Examination of Mine Gases and Natural Gas

The Bureau of Mines, as part of its designated duty of investigating the causes of mine accidents, is conducting at its experiment station in Pittsburgh, Pa., a study of mine gases. These investigations have necessitated making numerous gas analyses, many requiring special methods and designs of apparatus.

The methods described in Bulletin 197, just issued, are largely an outgrowth of the above investigation and are now used as standard methods at the gas laboratory of the Pittsburgh station of the Bureau of Mines.

Copies of Bulletin 197, "Sampling and Examination of Mine Gases and Natural Gas," may be obtained from the Bureau of Mines, Department of Commerce.

"International Standards Association"

Stimulated by several international undertakings of basic importance, the majority of which are in the mechanical industries, a meeting was held in New York, from April 13-22 last, at which a strong movement was initiated for the formation of an international body to develop and perfect industrial standards. In conjunction with this meeting and attending were members of the International Electrotechnical Commission from seventeen foreign countries.

This was the Third International Congress on Standardization and, by unanimous vote, agreement was obtained upon the draft for the Constitution of the new International Body which will be known as the "International Standards Association."

The aims and objects of the Association are stated as follows:

> "To lay the groundwork for international agreement upon standards by providing simple systematic means of interchanging information on the standardization work and activities in the different countries.
>
> "To develop general guiding principles for the assistance of the national standardizing bodies.
>
> "To promote uniformity among the standards of the various national bodies.
>
> "It is the intention of the International Standards Association that its work shall include the approval of international standards and the administrative machinery herein set up is so designed that it may be readily extended or modified to include the approval of such international standards when sufficient experience has been acquired."

The members of the International Standards Association are to be the central national standardizing bodies existing in the different countries, one for each country accepting this constitution.

The chief executive body is to be the "Plenary Assembly," composed of delegates of all the national bodies, with the final authority resting with the latter. Provision is also made for an "Administrative Council," with control of finances and administrative matters, and with advisory powers in important questions.

Work on technical questions will be in the hands of "technical committees," with official representation from each country interested.

During the sessions of the conference informal negotiations were opened with the International Electrotechnical organization in regard to a unified organization. Effort will be made to accomplish this before the first meeting of the "Plenary Assembly."

In connection with the main conference, informal conferences between technical experts were held on the subjects of screw threads, bolts and nuts, limits for fits, preferred numbers, and ball bearings.

The conference was called by the American Engineering Standards Committee, and was presided over by its Chairman, Mr. C. E. Skinner.

Sesquicentennial Exposition

We shall endeavor to give each month a list of events, of special interest to engineers, as scheduled for the succeeding month. The general schedule for June, as recently issued, calls for:

American Association of Engineers Convention—June 13th to 19th.

Society of Industrial Engineers Convention—June 16th to 18th.

Public Utilities Advertising Association—June 19th to 24th.

In addition to the above, there will be a large number of most interesting events beginning with the elaborate program on "Opening Day," which will occur May 31st. During June there will be a number of regattas on the Schuylkill River, special State Days celebrated in the Stadium at the Exposition, many conventions of societies and fraternities, and a number of athletic events.

ENGINEERS AND ENGINEERING will be glad to furnish correspondents at any time with latest information in regard to the program of events at the Exposition.

Tau Beta Pi

At a recent meeting of the Tau Beta Pi, honorary engineering fraternity, a permanent organization of the Philadelphia membership was effected. Members of the fraternity who were not present at that meeting are urgently requested to communicate with Mr. Albert Saunders, Jr., 3729 Locust Street, Philadelphia, Pa.

The organizers of this new chapter are very anxious to enlist as members every member of the fraternity registered in Philadelphia or vicinity.

Conservation of Power in Industrial Plants

Discussed at a Meeting of

The Engineers Club of Philadelphia

February 16, 1926

Presiding Officer—Morning Session

Dr. Arthur M. Greene, Jr., Dean, Mechanical Engineering, Princeton University

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Mechanical Transmission Economies

By WILLIAM STANIAR,
Transmission Engineer, E. I. du Pont de Nemours & Co.

It is a pleasure to address this conference on the subject of belting and transmission 'because it offers the opportunity of bringing to your attention a very much neglected and abused link in the chain of industrial power operations. My remarks will be empirical because experience and observations are more beneficial to this particular phase of the subject than theory.

A Costly Inconsistency

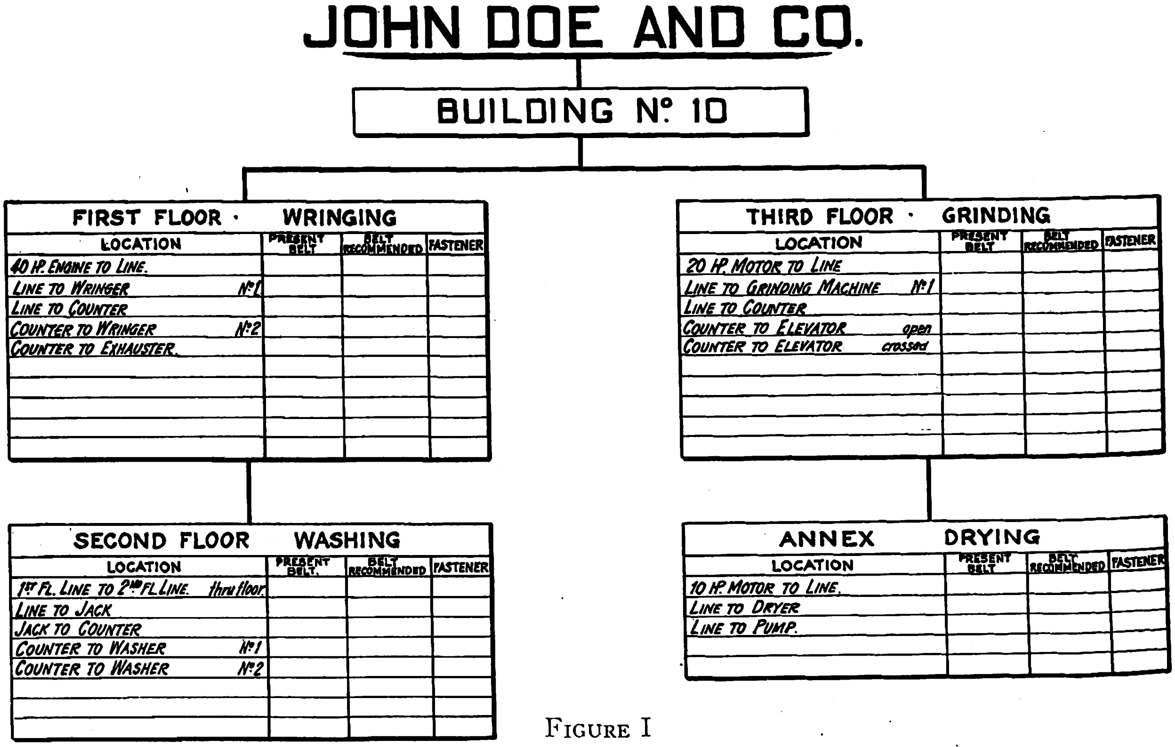
The transmission or distribution of mechanical power is vastly different from the transmission of electric energy in many and various ways, and these differences are not as a rule difficult to understand with the exception of one, and that is, why a majority of executive and plant managers have always underestimated and still, to a great extent, underestimate the importance of their power belting and mechanical transmission appurtenances. They demand expert engineering skill for the generation of their power and the selection and installation of apparatus, always with the idea of maximum protection at minimum cost but, when it comes to belting—the most widely used and indispensable link between that power and maximum production—they place the responsibility for its selection, design, installation and care upon untrained men, who use old rule-of-thumb methods, their own limited belting experience and consideration of first cost only, the result of which is poorly designed drives, loss of power and depreciation of belting and transmission equipment, which together constitute a heavy and unnecessary percentage of production costs.

However, this state of affairs cannot economically continue to exist in present day industrial operations because mechanical progress and competition are forcing the recognition that belting and transmission machinery are no longer necessary evils, to be selected at random, installed and operated by antiquated methods, but are essential and important parts of plant operation, requiring and deserving as much care and attention as any other part of the mechanical equipment. Therefore, in a conference such as this, it is only fitting that possible economies in the mechanical transmission of power should be brought to the attention of the engineering profession. Fundamentally, the problem of the engineer is to increase profits for industrial organizations by eliminating unnecessary leaks and the transference of power mechanically presents a very fertile field for this.

There is no doubt that the apparent lack of interest on the part of the average engineer in mechanical transmission is due to his failure to realize its vital importance and the possible losses involved. Therefore, it is my desire to create a picture in your minds of the relative importance of belting and mechanical transmission to economic industry.

The position of Belting and Transmission Engineer of a corporation as large as the Du Pont Company naturally affords opportunities for transmission of power testing and investigations almost without limit because, due to extensive and various operations, its belting and transmission machinery is called upon to operate under all kinds of chemical, atmospheric and mechanical conditions and naturally this would result in heavy losses in power, production and maintenance if some practicable method were not employed to arrest the effects of this unavoidable condition.

The average belting is easy prey for the deleterious fumes produced in chemical industries and, owing to the fact that explosives, dyestuffs, paints and varnishes, pyralin, artificial leathers, etc., are products of this industry, the Du Pont Company faces high power transmitting costs. The purchase of type, selection of sizes, installation and care of belting are most important. Type and brand cannot be bought on discount, selection of size for the power and mechanical conditions cannot be left to untrained men, installation cannot be made in a slipshod manner and the care of the medium left to chance, if economy of operation and production are paramount.



JOHN DOE AND CO.

BUILDING Nº 10

FIRST FLOOR · WRINGING			
LOCATION	PRESENT BELT	BELT RECOMMENDED	FASTENER
40 HP. ENGINE TO LINE.			
LINE TO WRINGER Nº1			
LINE TO COUNTER			
COUNTER TO WRINGER Nº2			
COUNTER TO EXHAUSTER.			

SECOND FLOOR WASHING			
LOCATION	PRESENT BELT.	BELT RECOMMENDED	FASTENER
1ST FL. LINE TO 2ND FL. LINE. thru floor.			
LINE TO JACK			
JACK TO COUNTER			
COUNTER TO WASHER Nº1			
COUNTER TO WASHER Nº2			

THIRD FLOOR · GRINDING			
LOCATION	PRESENT BELT	BELT RECOMMENDED	FASTENER
20 HP. MOTOR TO LINE			
LINE TO GRINDING MACHINE Nº1			
LINE TO COUNTER			
COUNTER TO ELEVATOR open			
COUNTER TO ELEVATOR crossed			

ANNEX DRYING			
LOCATION	PRESENT BELT	BELT RECOMMENDED	FASTENER
10 HP. MOTOR TO LINE.			
LINE TO DRYER			
LINE TO PUMP.			

FIGURE I

An Efficient System

The possible belting losses in all plants of the Du Pont Company have been curbed by the installation of the belting standardization system. This system of belting selection and control is a practicable and simple method for using the right belt in the right place as to type, width and thickness, because it is based on a detailed analysis of the following facts of each individual installation:

1. Conditions surrounding the drive, such as acid or acid fumes, heat, steam, moisture, grit, etc.
2. Power to be transmitted.
3. Speed ratios.
4. Diameter of pulleys, revolutions and velocities.
5. Center distance between shafts.
6. Method of control.
7. Angle of drive.
8. Top or bottom pull.
9. Method of loading.
10. Method of joining belt.

The analysis should result in each individual belt drive of the entire plant being scheduled in chart form, whether the belt in question is 3″ or 24″ wide, because in most cases the function of the 3″ medium is just as important as that of the 24″. The schedules or charts should be classified in accordance with the divisions of the plant and each divisional chart arranged in four columns; the first being headed "LOCATION," such as 50-hp. motor to head shaft; the second "PRESENT BELT," being the type and size of belt in use at the time of the analysis; the third "BELT RECOMMENDED," being the type and size recommended for the installation, based upon belting knowledge and the results of testing; the fourth "FASTENER," being the correct method for joining the belt recommended, based upon an intimate knowledge of belting substance and the diameter and speed of the minimum pulley over which the belt is to operate. (See Fig. 1). The building up of such schedules is greatly facilitated by existing plant belt records, that is, if they are comparable as to type, etc. However, if no records are available, it would be necessary to inaugurate a program of testing. This should be done sectionally, or one test of the various types for each acid, heat, steam, moisture or grit condition existing and, of course, the mechanical conditions involved. It should be borne in mind, however, that reliable belting performance tests, under actual operating conditions, are, as a rule, difficult to obtain because they are generally affected by the personal opinions and preconceptions of maintenance forces and operators. Therefore, particular pains should be taken to eliminate the personal equation in this work.

The standardization and schedule system of industrial belting is not a hypothesis. It is an actual working system now in operation in all large plants of the Du Pont Company and two of the largest of the General Motors Corporation, because it does not permit the selection and installation of belting to be left to guesswork. Furthermore, it removes belting problems from the mind of the Plant Engineer and, by eliminating multiplicity of types and sizes purchased, it lowers belting inventory.

Results Obtained

Investigations have shown that, where there is no systematic method of mechanical power transmission control, belting and maintenance costs generally follow production labor costs; therefore, it has been interesting to note the effect of the schedule system on this relation. In one large plant recently belting-surveyed or scheduled, production labor increased from $30,000 in January to $120,000 in August and the belting costs increased over the same period from $1,000 to $5,000, this being before the control system went into effect. During the latter part of August the belting schedules were placed throughout the plant and, by October of the same year, the tendency of belting costs was downward, while the labor costs continued upward. By the following February or March there appeared a marked effect. Belting costs had dropped to $3,000 with production labor at $105,000. This proves the value of belting control and its almost immediate effect on plant costs. It also proves that belting standardization is a most dependable protection against the invisible losses of this method of transmitting power.

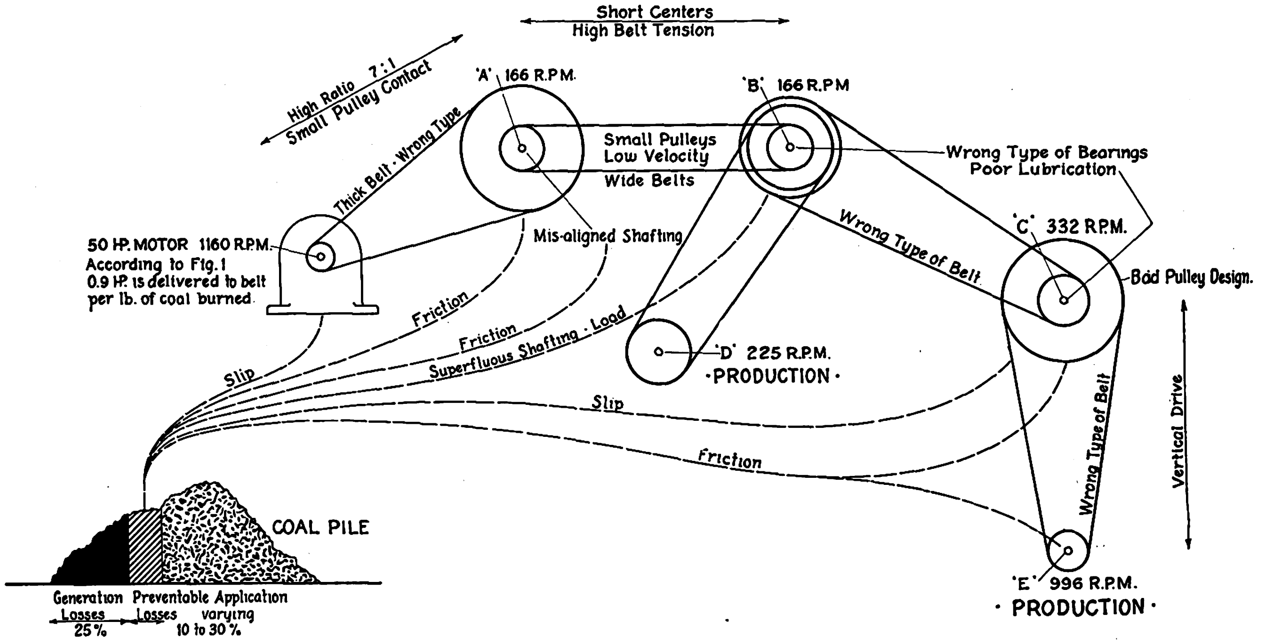
To a great many industrial plant managers, engineers and purchasing agents, belting, through a peculiar mental conception of theirs, takes the form of merely strips of material connecting one pulley with another, this view being caused, no doubt, by their failure to realize that belting is power transference. In its fullest sense it is the medium of delivering a given amount of energy at a given point at the least cost per unit of time, which should result in the transmission of this energy at the lowest cost per horse-power per year over the longest period of useful service. Simply expressed, it is to a great extent the connecting link between power and production. The belting to a belt driven machine or piece of apparatus is really more important than any other integral part of it. If its slips, production is retarded; if it fails, production ceases and, today, maximum capacity production is essential. The average automatic belt-driven machine tool ranges in price from $3,000 to $5,000 and, as a producer and dividend payer, it is worthless without its driving belt, which has a value generally in the neighborhood of $50.00. Therefore, the profits on the major investment are controlled by the $50.00 item. The automatic tool is a dependent and, by itself, cannot produce; its earning power is controlled by the belt and all the mechanical power transmitting accessories necessary and, while the cost of the belt is only one one-hundredth of the total, its selection should receive serious thought, not based on a comparison of the relative costs of the tool and belt, but on their relative worth, because the belt is the governing factor. Any belt-driven mechanism is producing efficiently only just so long as its belt is operating efficiently and this cannot be, unless it is of the proper type for the surrounding atmospheric conditions and the proper width and thickness for the pulley design, speed and power requirements.

More power for less money should be the aim of every factory executive and industrial plant manager. It is a practical aim and a paying one. It is practical because almost one-half of the fuel now burned for power is actually wasted. Power or energy left to itself is a non-producer; it must be applied and, generally, the mediums of its application are mechanical; therefore, the mechanical distribution and application of generated power is most important to the economic welfare of the industrial world.

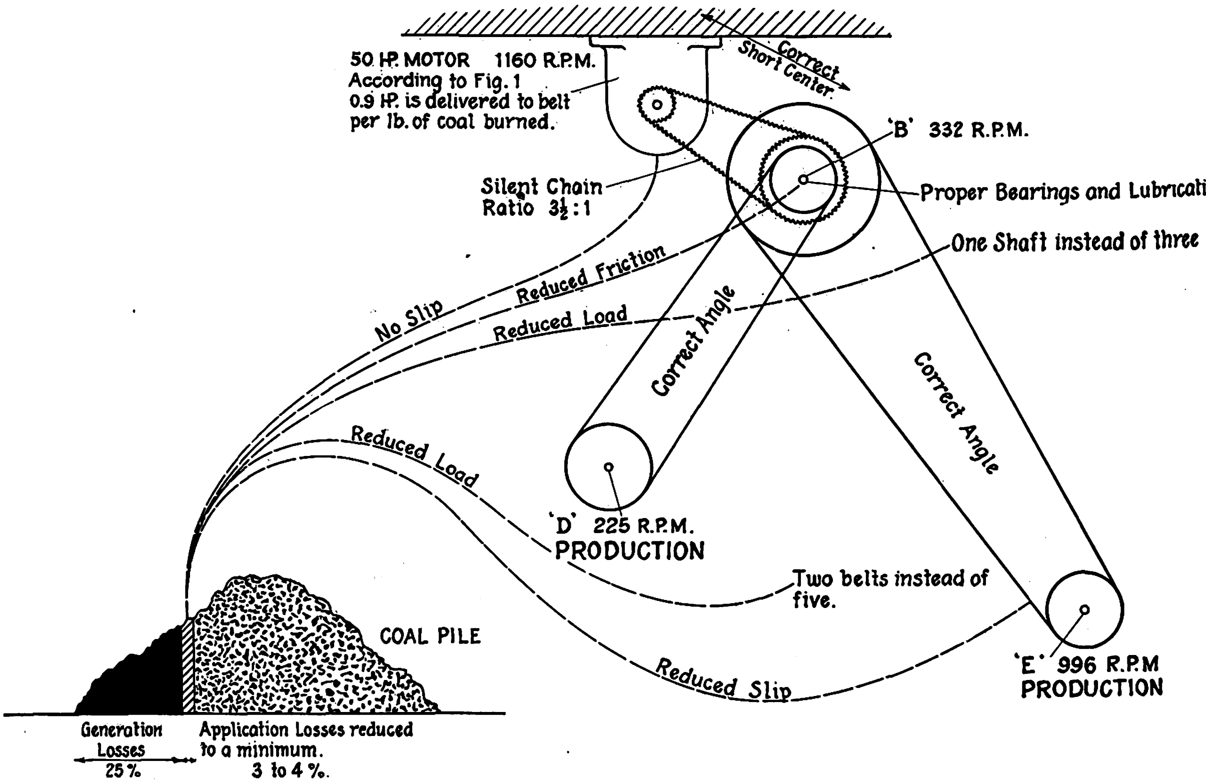
It is almost criminal to expend hundreds of thousands of dollars on elaborate and efficient power plants and then waste a large percentage of the energy generated by paying little or no attention to the most extensively used medium of transmission—belting. In a recent issue of the *Scientific American,* there appeared a pictorial sketch illustrating what becomes of the energy contained in a ton of coal. It designated boiler, turbine and generator losses and finally showed 0.9 horse-power delivered to the motor per pound of coal burned. It illustrated a belt leaving the motor pulley but there was no figure on this, the actual connecting link between the power finally available and production. An illustration such as this proves that the importance of belting to power, power conservation and profits is not generally realized. The 0.9 horse-power delivered to the motor from boiler, turbine and generator is worth only as much as the connection mediums will transmit to the final power consumer. The links of this power chain cannot be segregated; one must be as strong as the other, because they are inter-dependent. Modern engineering and power generating apparatus are gradually reducing the generating losses depicted in the sketch referred to and, in a similar manner, modern engineering is offering ways and means for the elimination of power waste between the motor and application.

An Actual Case

As an example of the possible losses beyond the motor, I will show you, by the figures herewith, a condition that actually existed in a plant recently inspected and what was done to reduce the loss to a minimum. This condition of mechanical power distribution is not unusual. Similar power wasting and coal consuming installations are plentiful because all beyond the motor is generally left to the untrained mind. The arrangement of belting and mechanical transmission appurtenances shown in Fig. 2 was daily creating a loss of approximately 10 to 30 per cent on the coal pile. Shaft "A", running at 166 r. p. m., was a short head driven by a thick non-flexible belt from a 50-hp. motor at 1.160 r.p.m., thus creating a ratio of 7 to 1 between driver and driven. It is obvious that 10 to 15 per cent slip is possible here, due to a stiff belt


Short Centers
High Belt Tension
High Ratio 7:1
Small Pulley Contact
'A' 166 R.P.M.
'B' 166 R.P.M
Small Pulleys
Low Velocity
Wide Belts
Wrong Type of Bearings
Poor Lubrication
Thick Belt · Wrong Type
50 HP. MOTOR 1160 R.P.M.
According to Fig. 1
0.9 HP. is delivered to belt
per lb. of coal burned.
Mis-aligned Shafting
Wrong Type of Belt
'C' 332 R.P.M.
Bad Pulley Design.
Friction
Friction
Superfluous Shafting · Load
'D' 225 R.P.M.
·PRODUCTION·
Slip
Slip
Friction
Wrong Type of Belt
Vertical Drive
COAL PILE
Generation Losses 25%
Preventable Losses
Application varying 10 to 30%
'E' 996 R.P.M.
· PRODUCTION ·

· FIG. 2 · FAULTY APPLICATION OF AVAILABLE POWER · ANOTHER DRAIN ON THE COAL PILE ·


Correct Short Center
50 HP. MOTOR 1160 R.P.M.
According to Fig. 1
0.9 HP. is delivered to belt
per lb. of coal burned.
'B' 332 R.P.M.
Silent Chain
Ratio 3½:1
Proper Bearings and Lubrication
One Shaft instead of three
Reduced Friction
No Slip
Reduced Load
Correct Angle
Correct Angle
Reduced Load
'D' 225 R.P.M.
PRODUCTION
Two belts instead of five.
COAL PILE
Reduced Slip
'E' 996 R.P.M
PRODUCTION
Generation Losses 25%
Application Losses reduced to a minimum. 3 to 4%.

· FIG. 3 · CORRECT APPLICATION OF AVAILABLE POWER IN FIG. 2 ·
· REDUCES DRAIN ON THE COAL PILE ·

operating on a high speed small pulley with reduced contact. Shaft "B" was the line-shaft, belt connected to shaft "A" and operating at the same speed. Shaft "B" could have been driven direct from the motor but, at the time, it was thought a simpler matter to install as shown, instead of removing a few obstacles, so a short center wide belt was employed to drive shaft "B" from "A". Small diameter pulleys were used, thus creating low velocity and necessitating a wide and tight belt to transmit the required power. This caused excessive bearing pressure on shafts "A" and "B," with consequent friction and power loss. Shaft "B" distributed its power to a battery of machines at "D" and to a large grinding machine at "E", through a countershaft "C". The chief function of the countershaft "C" was to make possible a speed ot 996 r.p.m. on the grinder. The position of this counter, in relation to the grinder, necessitated a vertical high tension belting installation, causing excessive bearing pressure on both counter and machine and excessive slip due to the vertical position of the belt. Further, inspection of this particular layout proved bearings to be of cheap construction and poorly lubricated, the shafting out of line and the pulleys not suitable for the work.

It is evident that the misapplications indicated resolve themselves into two direct tangible losses, one on the fuel to the extent of 10 to 30 per cent and, in some extreme cases, as high as 50 per cent and the other on production to, no doubt, the same degree. Similar cases of power application abuse are prevalent throughout the country, some not so glaring, some worse but, nevertheless, the general waste of power from the prime mover to production is, in many cases, in excess of the losses due to generation and should be given attention, because loss is waste and preventable waste is expensive and unpardonable.

That wasteful applications such as is demonstrated in Fig. 2 can be eliminated, is proven by Fig. 3. By the removal of a few obstructions, the 50-hp. motor was suspended from the ceiling and the line shaft "B" silent chain connected to it but, instead of the line being operated at 166 r.p.m., the speed was increased to 332 r.p.m. so as to accommodate the required speed of 996 r.p.m. on the grinder. The head shaft "A", the countershaft "C", the 7 to 1 reduction from motor to head, the short center high tension belt connecting "A" with "B" and the vertical belt from "C" to grinder were all done away with by this one change. This slight attention and alteration saved at least 8 to 26 per cent on power, production and maintenance on one 50-hp. installation. Savings such as these can be accomplished in almost all plants of the country, where old methods are employed, if the management will sanction the initial cost of the change. They should; because, in mechanical installations of moderate power capacity, the return on the investment is immediate and lasting, not only to themselves but also to the natural resources of the country.

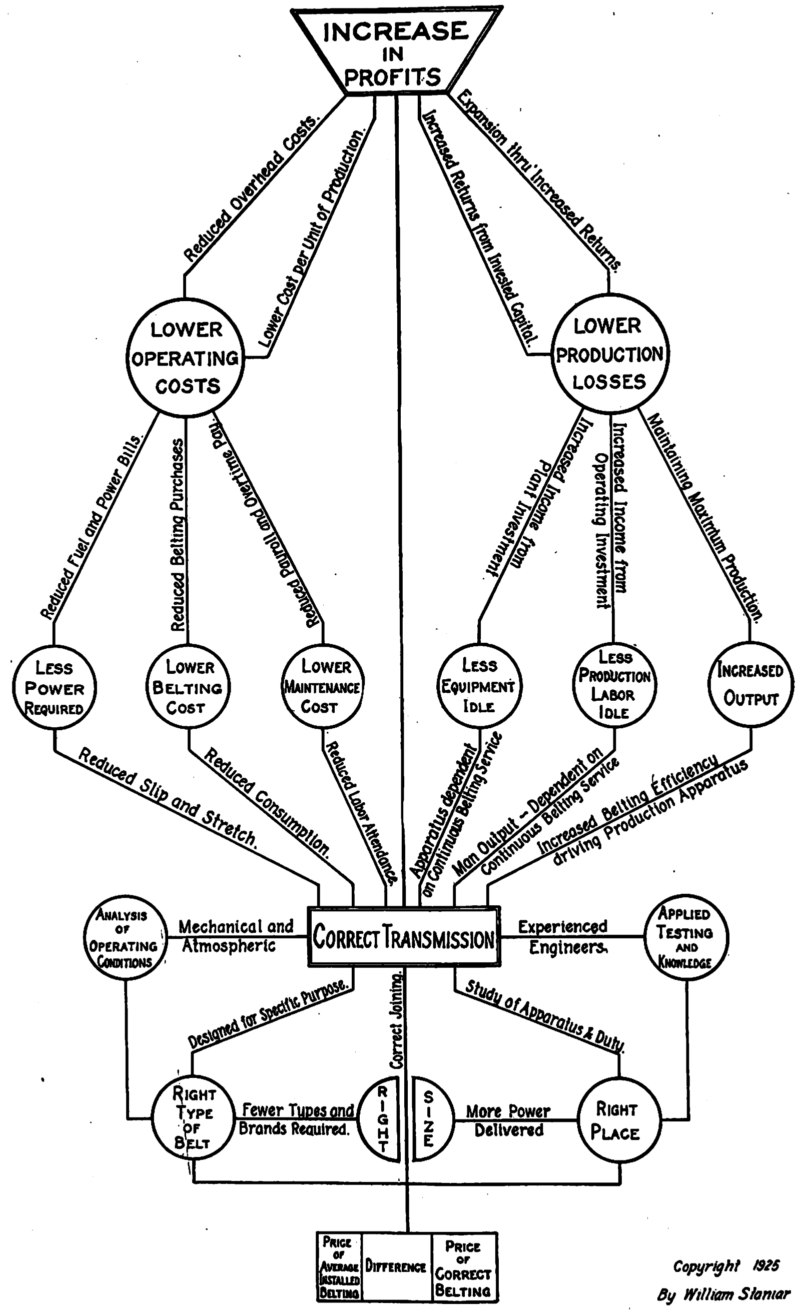
New Work Also

Power wasting transmission installations are not always confined to old plants. Many modern establishments can exhibit glaring examples but, in the majority of these cases, it is not through the lack of knowledge or consideration of modern methods and equipment. It is because the transmission of mechanical power has been forgotten up to the last moment. Great care has been given by the designers to type, style and size of buildings and all materials entering into their construction; great skill has been displayed in the arrangement of apparatus; the finest kind of heating and ventilating equipment has been specified; then, finally when it is all set and ready to operate, it is suddenly realized that the actual production apparatus must be driven and driven mechanically. What is the result? Motors, shafting, belting, speed reducers, etc., must be squeezed into small spaces and impracticable methods employed because the plant must be operated and any way is the best way regardless of the power, maintenance and production losses.

In almost all plants of the country, whether they be of the modern or old style construction, the shafting and belting system is the most extensively employed owing to its flexibility as to load and distribution. However, developments of recent years have brought methods and systems, for the economical distribution of mechanical power, that were never heard of in the past and, no doubt, electrical research and the perfecting of the electric motor are responsible for the divorce of industry from the old power-consuming methods of transmission. Mechanical inventive genius has kept pace with electrical development because it was realized that the high speed energy of the motor could not be applied to the general run of machinery without suitable and economical reduction methods. Therefore, many systems such as direct flexible coupled motor connection, worm and spur gear reduction units, roller or silent chain connections, modern idler systems or direct exposed gear reductions have been devised for accomplishing this purpose. All of these methods or systems have their place and should be considered during the design of new work and as improvements on existing operating installations.

Influence on Profits

That the scientific control and selection of the most extensively employed medium of power application has a direct influence on the profits of a manufacturing organization, I will endeavor to show you graphically. The chart (Fig. 4), has been prepared for this purpose. The left-hand side of the chart presents the effect on plant operation; the right-hand on


INCREASE IN PROFITS
Reduced Overhead Costs.
Lower Cost per Unit of Production.
Increased Returns from Invested Capital.
Expansion thru' Increased Returns.
LOWER OPERATING COSTS
LOWER PRODUCTION LOSSES
Reduced Fuel and Power Bills.
Reduced Belting Purchases
Reduced Payroll and Overtime Pay
Increased Income from Plant Investment
Increased Income from Operating Investment
Maintaining Maximum Production.
LESS POWER REQUIRED
LOWER BELTING COST
LOWER MAINTENANCE COST
LESS EQUIPMENT IDLE
LESS PRODUCTION LABOR IDLE
INCREASED OUTPUT
Reduced Slip and Stretch.
Reduced Consumption.
Reduced Labor Attendance.
Apparatus dependent on Continuous Belting Service
Man Output - Dependent on Continuous Belting Service
Increased Belting Efficiency driving Production Apparatus
ANALYSIS OF OPERATING CONDITIONS
Mechanical and Atmospheric
CORRECT TRANSMISSION
Experienced Engineers.
APPLIED TESTING AND KNOWLEDGE
Designed for Specific Purpose.
Correct Joining.
Study of Apparatus & Duty.
RIGHT TYPE OF BELT
Fewer Types and Brands Required.
RIGHT
SIZE
More Power Delivered
RIGHT PLACE
PRICE OF AVERAGE INSTALLED BELTING
DIFFERENCE
PRICE OF CORRECT BELTING

Copyright 1925
By William Staniar

FIGURE IV

production. "Good belting, regardless of price," generally places the right belt in the right place. Stretch and premature failure are the cause of high maintenance costs, because they necessitate frequent adjustments and replacements. Correct belt transmission also depends on correct belt joining, which in itself has a great effect on maintenance and production costs.

If the control of mechanical power transmission results in less power required and lowers belting and maintenance costs, it is evident that power operating costs will follow this trend through the mediums of reduced fuel and power bills, belting purchases, payroll, and overtime expenses. Lower operating cost resolves itself into increased profits through reduced overhead and lowering the cost per unit of production.

Correct belt transmission has a marked effect on the costs and efficiencies of production, because the great majority of production machinery is belt-driven. Therefore, controlling the selection and application of this medium results in less idle equipment, which in turn results in less idle skilled production labor. Output or production of any machine is dependent on a certain definite number of revolutions per minute of its prime mover and, if misapplied belting interferes with this, it is manifest that the rated capacity of the machine will be lowered. Therefore, correct belting has an increasing effect on production because it obviously maintains the rated speed of the production apparatus. Increased production based on the lowering of manufacturing losses resolves itself into plant expansion through increased returns from capital invested and this again results in increased profits to the company.

DISCUSSION

QUESTION: Suppose you buy a machine tool for which you decide the pulleys are not of adequate size for the horsepower recommended by the people. Do you redesign the machine or decrease the size of the motor?

MR. STANIAR: That is a point that has been a very strong one with me. The average machine tool builder, and pump builder, does not furnish adequate pulleys for his apparatus; and we are up against it all the time. We cannot put an adequate belt on for the power, and we have to stand the loss.

QUESTION: How much of the saving due to the installation of proper belting is used up on clerical work?

MR. STANIAR: Practically none. After the experiment is made it is a continuous proposition, just as in the lubrication end. Sometimes the Engineering Department will check up to see if I put on the right belt; but the clerical work is practically nothing.

Lubrication—A Factor in the Conservation of Power

By JOHN D. GILL
of the Atlantic Refining Company

PROBABLY not more than 11 per cent of the energy of fuels used for the production of power is delivered from prime movers. A part of this 11 per cent is lost through the friction of rubbing surfaces, giving rise to the problems of lubrication. The loss of energy through friction may represent a total of 2 to 3 per cent of the energy in the fuel, an apparently insignificant amount. Compared to the losses arising from incomplete combustion, losses of heat in smoke, losses of heat in the exhaust, and losses by radiation, the loss by friction has appeared negligible, and undoubtedly has been responsible for the general disregard of the problems of lubrication.

Multiplied Saving

The insignificant but obvious direct cost of lubricating oils, compared with other costs of producing power and of manufacture, also has belittled the problems of lubrication; and especially so because the obvious, insignificant cost of oil was not often brought into clear relationships with the very significant but obscure effects of friction. The importance of the problems of lubrication becomes startlingly evident on recognition of the fact that ten pounds of fuel are saved at the furnace door for each pound in equivalent energy saved by the reduction of friction; and that a dollar invested in lubrication may save directly $10.00 worth of mechanical energy.

The following schedule (Figure I) shows the magnitude of our power problems.

PRIMARY DEVELOPMENT OF POWER

Class	Energy Developed	Coal Equivalent (2,000 lbs.)
Public Utilities	88,200,000,000 HP. Hrs. (1925)	68,000,000 Tons
Manufactories	59,000,000,000 HP. Hrs. (1923)	37,000,000 Tons
Mines & Quarries	19,000,000,000 HP. Hrs. (1919)	19,000,000 Tons
Steam Railways	74,500,000,000 HP. Hrs. (1922)	126,000,000 Tons
Electric Railways	16,600,000,000 HP. Hrs. (1922)	14,000,000 Tons
Marine	21,400,000,000 HP. Hrs. (1923)	17,000,000 Tons
	278,700,000,000 HP. Hrs.	281,000,000 Tons
Automotive, etc.	96,600,000,000 HP. Hrs. (1925)	74,000,000 Tons (222,000,000 Bbls. Gaso.)

FIGURE I

Exclusive of automotive power, the United States is developing approximately 300,000,000,000 horse power hours of energy annually. This tremendous energy requires the use annually of 281,000,000 short tons of coal, or its power producing equivalent of other fuels, and requires an investment in power generating equipment estimated to be in excess of $12,000,000,000. The value of the energy developed annually at our present rate of production is probably not far from $5,000,000,000.

How much power is lost by friction throughout the country is of course problematical. The friction losses vary greatly with the different classes and sizes of generating, transmitting and utilizing machinery; from something less than 2 percent on certain electrical machines to more than 60 percent on some inefficient line shafts and utilizing equipment. The friction horse power of prime movers may be as low as 3.5 per cent of the indicated horse power for large, well designed and efficiently operated engines, and as high as 25 percent in smaller units. Professor Fernald states that losses of 40 to 60 per cent occur between the engine and process machinery, and that the over-all friction of locomotives varies from 10 to 30 per cent. The problem of power saving by lubrication would be simple were the sliding surfaces of the prime movers only to be considered. The greatest losses, however, occur beyond the prime mover, to which but little attention has been given.

$500,000,000 Yearly Saving

How much the frictional losses can be reduced for the country at large is also problematical. In certain cases, friction losses have been reduced by 50 percent; indeed, changes of this magnitude have been made by change of the lubricant only, and the possibilities may be indicated by the fact that changes from 15 to 20 percent in friction losses have been observed simply through a change in operating temperatures. For the purposes of the present discussion, an assumption of a possible saving of 10 percent of the total power input of the prime movers will not be considered extravagant.

It is, of course, the controllable element of friction with which we are concerned. A 10 percent saving of power represents a power value of $500,000,000, including 28,000,000 tons of coal. Only six days ago, a prominent manufacturer of anti-friction bearings featured prominently, in an advertisement in an evening paper of this city, an offer to prove that his "anti-friction equipment can reduce coal consumption 15 to 20 per cent a year," equal to 50,000,000 to 100,000,000 tons of coal a year.

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[*] Paper read before The Engineers Club, Philadelphia, February 16, 1926.

Reduced Investment Also

Perhaps it is with respect to the possibility of minimizing investment in power equipment that the value of lubrication should be stressed. A foot pound of energy saved by lubrication is a foot pound less required of the prime mover. A saving of 10 percent of the power generated, now lost in friction, would permit an expansion of power consumption equivalent to the building of power plants worth about $1,250,000,000 on the basis of the estimated cost of existing power plants. The interest and depreciation on this investment alone is equal to $150,000,000 annually. It is worthy of special consideration that no improvement in combustion efficiency, in the reduction of radiation losses or reduction of losses in the exhausts of prime movers has any effect on the economy of operation beyond the prime mover; on the other hand, any saving by the reduction of friction in utilizing, transmitting, and generating equipment beyond the prime mover has a multiplied effect in reducing the required size of prime mover, piping, stack, boilers, auxiliary equipment and houses for same. The importance of this phase of the subject will of course be more manifest in considerations of the power needs of the future, to be discussed briefly hereafter.

It is indeed unfortunate if the buyers of lubricating oils have permitted the comparative smallness of their oil bills to obscure the importance of the function of the lubricant. Last year about $47,000,000 was spent for oils, exclusive of process oils for textile mills, tanneries, heat-treating, cutting of metals, etc., for the lubrication of power worth about $5,000,000,000, a cost for lubricants of about 1 per cent of the cost of power generated, transmitted and consumed. All classes of machinery shared the 215,000,000 gallons of oil, about ⅔ of a gallon of oil per thousand horse power hours. Against this small cost for oil how large appears our estimate of a conservative saving of $500,000,000 by better lubrication!

Lubricants and Lubrication

The charts, Figures II and III, showing the relation between the supply of lubricant and the frictional coefficient, and the relation between the viscosity of lubricants and frictional resistances, illustrate the fundamental reasons why friction losses are so large, and point to the means for their reduction: First, the effect of restricted feed of lubricant on increasing friction; second, the effect of increasing friction by the use of an oil selected with minimum oil supply as the objective. Friction losses are high on machinery as found because of the lack of economical methods for the plentiful supply of oil to rubbing surfaces, and because of the improper selection of the viscosity of the lubricant. For the most part the former cause determines the latter.

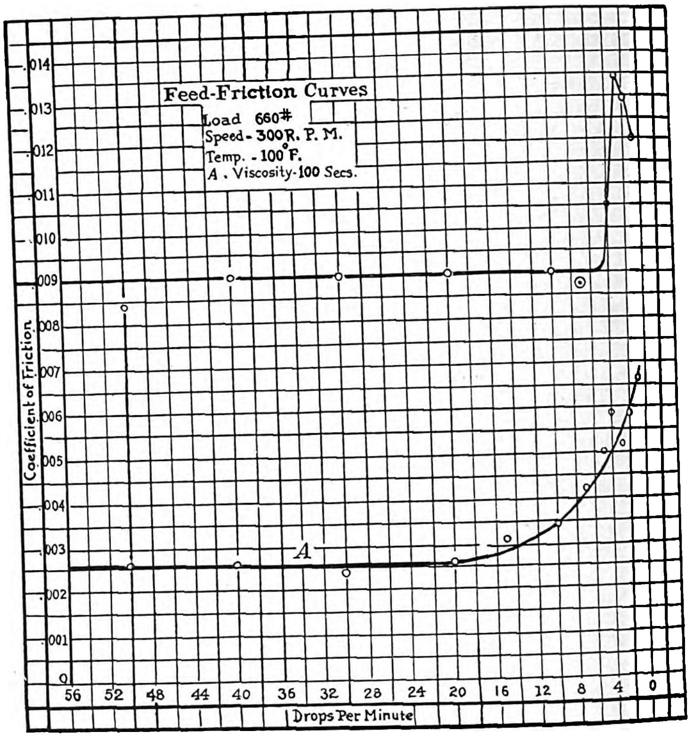

FIGURE II

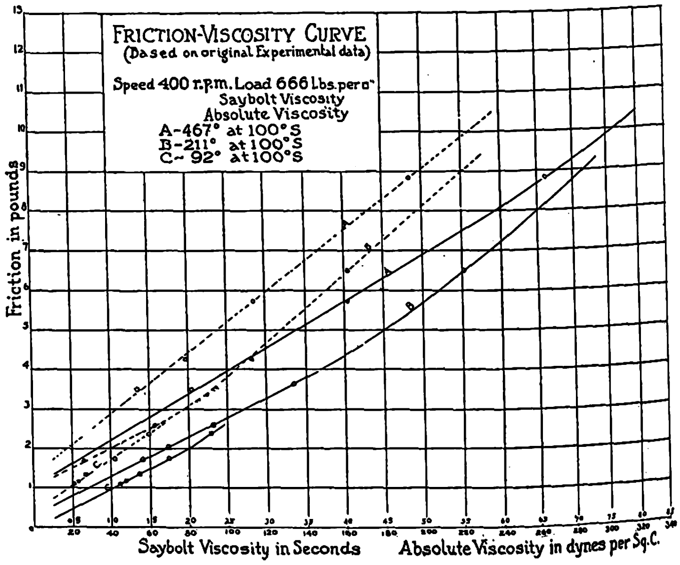

FIGURE III

The art of lubrication, one might say the science of lubrication, is sufficiently developed to make possible large reductions in friction losses on existing equipment; and by better design to avoid large friction losses on equipment to supply future needs. What is needed is an appreciation of, and desire for, the attainment of these possibilities.

What Designers Must Know

Designers of machinery for the future must know and apply the fundamental principles of the friction of well lubricated surfaces; first, that the difference between the friction of flood lubricated and dry or indifferently lubricated bearings is so great as to demand superior, positive methods of oil supply to supersede the common intermittent supply from a squirt can through a hole in the bearing casting to the journal, (the facts of Figure II demonstrate this principle); second, that such flood lubricated bearings will withstand much greater bearing pressures, and therefore permit the use of bearings of less circumferential area. The importance of area on the frictional values of well lubricated surfaces is expressed in the following formula for the horse power loss in a journal bearing lubricated with an oil of unit absolute viscosity, in which it is assumed that the journal and bearing are concentric at the speed of rotation:

$$HP. = \frac{0.000,000,01904\ N^2\ D^3\ L}{t}$$

in which

N=R.P.M.,
D=Diameter of journal in inches,
L=Length of bearing in inches,
t=½ of bearing clearance in thousandths inch.

The relations between the Saybolt universal viscosimeter values and absolute viscosity follow:

Saybolt Viscosities	Absolute Viscosities ÷ Sp. Gr. of Oil
60	.10
100	.21
200	.43
300	.65
400	.87
500	1.10

The designer will consider carefully the relations between the unit pressure over the projected area of the bearing and the viscosity and rubbing speed of the journal. The formula is

$$P = K\sqrt{v}$$

in which P = Critical or breakdown pressure
K = A constant for the particular type of bearing
and v = Rubbing velocity in feet per minute.

For a particular case of a partial bearing, K had a value equal to ⅙ of the critical or breakdown viscosity. Heretofore, the viscosity of the oil has generally been disregarded in formulas used in the design of bearings.

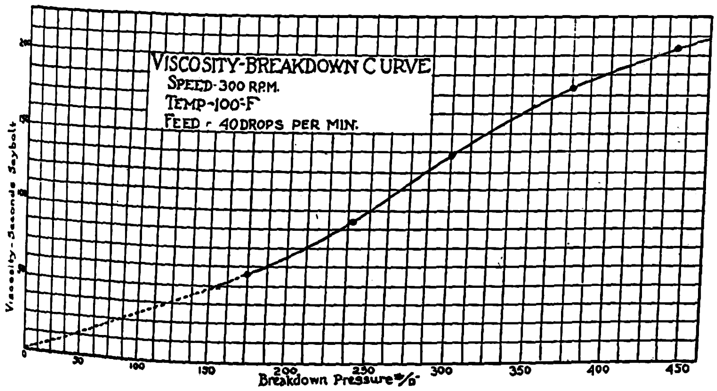

FIGURE IV

The relationship between the pressure carrying power of a bearing and the viscosity of the lubricant is shown in Figure IV, plotted from data experimentally obtained.

Consideration will also be given to the fact that,

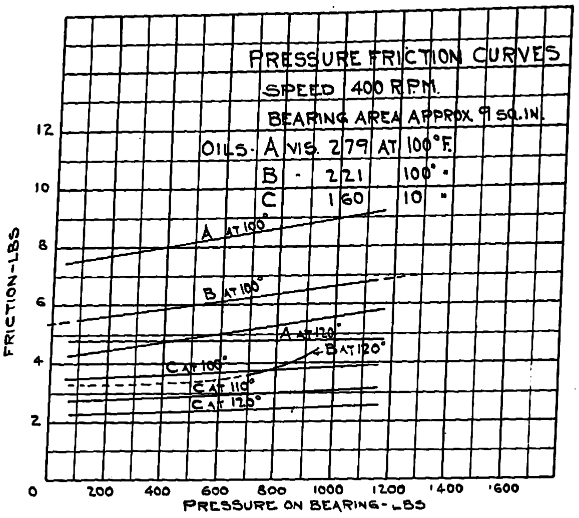

FIGURE V

as long as the viscosity of the lubricant will maintain the condition of perfect lubrication (complete separation by a continuous oil film), that long the frictional values are approximately constant, regardless of the magnitude of the bearing pressures. Figure V depicts experimental proof of this statement.

Machines of the Future

It is not too much to suppose that machines of the future will bear tags specifying the viscosity of the oil to be used thereon, an action taken by designers who have given consideration to the factor-of-safety applying to the particular method of supplying the lubricant which has been adopted, viz., flood feed, ring-oiled, sight-drop feed, etc. Of course, such procedure infers standardization of design of bearings; otherwise confusion would result from the multiplicity of lubricants required.

Considerable reduction of friction losses can be made on existing equipment by the more extensive use of lubricating devices and supervision, for the more plentiful supply of oil to rubbing surfaces and by the adoption of an open mind towards the offers of informed oil salesmen and engineers who are anxious to be economically more useful by assisting in the selection of more suitable viscosities. For certain purposes other properties of oils besides viscosity must be considered. Time, however, will not permit their discussion now.

The probable demands for power in the future require now that we give attention to the problems of lost energy through friction. The Bureau of Census announced that manufacturing industry alone had installed in 1923, 33,094,000 primary horse power, a figure just 50 percent higher than the primary horse power installed in factories in 1914. The demands for power in manufacturing appears to increase as the third power of the increases in population. It has been estimated that by 1950, 100,000,000 primary horse power would be used in manufacturing and, by 1975, industries would have 170,000,000 primary horse power. No doubt, analysis would indicate somewhat similar increments for transportation and other power requirements. Such prodigious demands for power point clearly to the need for conservation of fuel and the mechanical energy derived from it.

DISCUSSION

QUESTION: Would the relation shown in Fig. 2 hold with a heavier load per square inch?

MR. GILL: It would hold with a heavier load per square inch up to a certain critical pressure. There is a certain relationship between the pressure of the bearing and the viscosity of the oil applied to the bearing. If I did not say another thing this morning, I think I would have said something of value in these two remarks: namely, that the loss of energy in friction is due, first, to insufficiency in the supply of oil, and, secondly, to the selection of oils of higher viscosity than should be chosen for the particular combination of load, speed and pressure.

Economy Due to Power Factor Correction*

By ERB N. DITTENHOFER
Engineer, Research Department, Gotham Industrial Corporation

IN a full-fashioned hosiery mill the average load conditions are bad, due to the operation of a large number of small induction motors—generally of 1.5 H. P., which operate at an average power factor of from 30 to 40%.

These conditions were especially bad at the plant of the Gotham Silk Hosiery Company, as was evidenced by an overall Power Factor of only 49.9%. The feeder circuits were badly overheated and there was an excessive blowing of fuses. On one circuit in particular a 300 amp. fuse had been substituted for one of 100 amp. and even this blew several times a week. In addition, the two transformers were considerably overheated and there was grave danger of a costly shut-down.

At this time the load conditions were as follows:

(1) 106 knitting machines on six floors of two old buildings—each floor being driven by a 15 H. P. motor.

(2) 21 knitting machines on the fourth floor of No. 2 building, each driven by a direct connected 1.5 H. P. motor. It was on this circuit that the 300 amp. fuses had been installed.

(3) 85 knitting machines, in a new ten-story reinforced concrete mill, also driven by 1.5 H. P. motors. This load was to be eventually increased to 168 machines. One circuit fed the floors from the sixth to the second and another the remainder of the floors. These circuits consisted of 500,000 circ. mil. cables with panel boxes on each floor and No. 8 wire feeders to each group of four motors—of which there were six on a floor.

(4) A miscellaneous load in the machine shop, winding room, on the elevators, and the like.

Conditions in January, 1924, especially in the new mill, became so bad that although only about one-half of the proposed load was running it was found necessary to take the six group drive floors off central station service and drive them with an old 75 H. P. steam engine. This was done on the advice of the Philadelphia Electric Company and relieved the transformers sufficiently to remove all danger of a shut-down.

Two plans for correcting the Power Factor of the mill were suggested. The first proposed to raise the Power Factor to the required 90% by the installation of a group of static condensers at the metering point; the second proposed to instal individual condensers on all the direct drive machines and then to add whatever additional correction was necessary at the metering point.

In view of the fact that it would have proved necessary to install a new feeder in the mill at a cost of about $1,400 unless at least some of the correction was applied at the motor terminals, the latter plan was adopted.

The engineers of the National Electric Condenser Company proposed to install 1.5 KVA of correction on each of the 1.5 H. P. motors to raise their Power Factor to 65% and to install 120 KVA in group correction at the metering point. This would then raise the mill Power Factor to 90% when the plant was entirely equipped with machinery.

The first step made was to install 78 KVA in individual condensers at the end of the feeders in the new mill and on the 21 machine feeders in No. 2 mill. After this had been done it was found possible to put back the six floors on central station service and to replace the 300 amp. fuse with the original 100 amp. installation. The load in the new mill had increased 16 machines by this time and after an additional 93

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*Presented at meeting February 16, 1926, Engineers Club, Philadelphia, Pa.

KVA in individual condensers had been installed the two 100 KVA transformers had cooled down to 159 and 169 degrees Fahrenheit respectively with a room temperature of 85 degrees.

The mill Power Factor had now been raised from 49.9% to 70.3%.

Before any group correction was installed, it was decided to run a test on the group drive motors in the old mills and the load was found to be badly overmotored and to be operating at a Power Factor of only 52.7%. The six 15 H. P., 900 R. P. M. motors were replaced by two 10 H. P. and four 7.5 H. P., 1200 R. P. M. motors with a saving of 40 H. P. in a 90 H. P. load. These new motors were corrected with 9.5 KVA in condensers applied at their terminals which raised their Power Factor to slightly better than 91%. This motor change eliminated 37 KVA in group correction as originally planned.

By this time there was a total of 156 machines running in the three mills—individually driven—205 KVA in static condensers had been installed, and the plant Power Factor was 87.8%.

A study of the motor driving the direct connected machines was next made and it was found that motors with different characteristics than those supplied with the machines could be purchased which with 1.5 KVA in condensers applied at their terminals would give a Power Factor of better than 90%. The use of such motors on the remainder of the machines to be installed plus the installation of 20 KVA in individual condensers split between the winding room, the machine shop, and the elevators would entirely eliminate the necessity of any group correction at the metering point.

The last test made by the Philadelphia Electric Company showed an overall Power Factor of 91.4%.

The beneficial results obtained by the raising of the Power Factor from 49.9 to 91.4% may be summarized briefly as follows:

(1) The elimination of the Power Factor Penalty. This amounts to about $3,600 a year and is alone a splendid return on the Company's investment.
(2) A lower power consumption per unit of product.
    (A) Kw. Hr./Doz. Hose—Before=
    (B) Kw. Hr./Doz. Hose—After =
(3) Elimination of the necessity of an extra feeder.
(4) The showing up of bad motorization which in itself led to an appreciable saving.
(5) The cooling of transformers and feeders. Lower fuse capacity (from 800 amp. to 600 amp. in the new mill) with elimination of fuse trouble and better plant operation in general.
(6) The removal of all danger of a shutdown.

DISCUSSION

QUESTION: Is that saving of 27% made largely on the amount of decrease in the current consumed, or on the P. E. contract?

MR. DITTENHOFER: No, this figure was made entirely on amount of current consumed,—has been made entirely separate from any change in the Philadelphia Electric contract.

QUESTION: What was your total investment in condensers?

MR. DITTENHOFER: About $18,000. They paid for themselves in a little over a year and a half.

QUESTION: What was the total kilowatt capacity for the condensers?

MR. DITTENHOFER: Roughly 205 K. V. A. condensers.

QUESTION: What is the life of those condensers?

MR. DITTENHOFER: We haven't been able to get any figures on that. The National Condenser Company was there testing them. They have been in two years and they give great satisfaction. We understand their life is twenty years.

QUESTION: Have you tried the Flynn-Litzer Motor?

MR. DITTENHOFER: The designer could not make it small enough for our machine.

(Record of Meeting will be continued in June issue.)

Aero-Transportation

A Discussion Held Under the Auspices of

The Engineers Club of Philadelphia

March 16, 1926

"The Present and Future of American and Foreign Air Service"

By C. M. KEYS

President of the Curtiss Aeroplane and Motor Company, Inc., Chairman of the Board, National Air Transport, Inc.

THE subject matter of my speech, as I see it on the program, is "The Present and Future of American and Foreign Air Service." I am expected to tell you all about that in a fifteen-minute speech. That reminds me of the job of the monk in the dark ages who was given the task of engraving a long chapter from the Bible on a metal button three-quarters of an inch in diameter. The monk, however, accomplished his job—while I am not likely to accomplish mine. This will have to be in reality what one might call a tabloid speech.

Two Different Views

The two views of the subject are very different. Organized commercial aviation in Europe was born in 1919 and might now be called a seven-year-old child. Organized commercial aviation in the United States has barely been born, and has all the characteristics of an infant. It has to be nursed with the most assiduous care, and is probably the most completely spoon-fed industry in the United States at the present time. In Europe it is old enough to have acquired a few habits of a more or less settled appearance, so that one may judge of its present, and a little bit of its future. In America it has not gotten beyond the stage of making a lot of noise but doing not much else.

I have said the European industry has acquired a few habits. With all due respect to General Brancker and his very capable staff, who hold the destiny of British commercial aviation in their hands, and with equal respect to the organizations of the French, German and Belgian governments, which perform the same functions in their respective countries, most of the settled habits of the European industry look to us on this side of the water like rather bad habits. This youthful industry has already acquired a very settled habit of spending about twice as much money as it can make. So far as the published records indicate, there is hardly a unit in the European commercial airways which does not spend more than $100 for every $50 that it takes in from its service, drawing for the remainder upon the overburdened taxpayers of the respective countries.

Commercial aviation on that basis strikes me as a seven-year-old boy who has not yet acquired the habit of standing on his feet and walking, but who insists, on the contrary, on being transported in the paternal automobile wherever he wants to go. The immutable law of nature is that such a boy, unless he changes his ways, will grow up spindle-legged and hollow-chested, and early in life will become the patron of an undertaker.

Fortunately, however, the sole object of commercial aviation in Europe is not the making of money. The development of continental lines by Great Britain serves a great political purpose as a start in the development of links between the scattered units of Britain's far-flung empire. The development of commercial lines in France began with the military motive and still has that motive, and is, therefore, a strong measure in the national defense. Germany's backing of the Junkers is one of the few gestures of self-defense permitted to Germany under the Treaty of Versailles. It is presumably in part for these services, the importance of which no alien can measure, that the taxpayers of Europe are not merely willing, but glad to assist in building up the commercial lines. Whatever may be the motive, the fact remains that practically all the operating lines of Europe are subsidized directly or indirectly, and to an extent which cannot be appreciated by an American audience.

It would be impertinent on my part, in view of the fact that General Brancker, who probably knows more about commercial aviation in Europe than any other living man, will address this conference tonight, to go into details with respect to the scale or basis of these operations. I am content to draw my conclusions on this subject from General Brancker and his associates, rather than to entertain any half-baked conclusions of my own—and I am confident enough, not only in the art of flying but also in the native common sense of the commercial leaders of Europe, to entertain a hope that in the course of time the necessity for subsidies and subventions in Europe will disappear, and that the spindle-legged boy of today will grow up to be a very sturdy citizen of the industrial world and a credit to himself and the great nations which he serves.

The Problem of America

Let us turn now to the problem of America. We have begun to realize what that problem is. Almost everyone who has written or spoken about this subject has started out by saying that America is far behind Europe in commercial transportation by air, and by expressing a regret that America, which invented the aeroplane, is the last of the great nations to use it for profit. I want to discuss that fundamental statement. I assume that I am talking to a group of people very few of whom know much about flying. I will therefore try to make what I have to say a little clearer than I would feel it necessary to make it if I were talking to a group of flying people.

Commercial aviation divides itself into two great branches:

1. Organized flying operations on schedules.
2. Flying service.

It is perfectly true that, as far as organized flying operations are concerned, America has started very late. There is not in operation in the United States today a privately owned transportation company of any great magnitude flying ships on schedule for the transportation of either passengers, mail or express. There are dozens of such lines in Europe, subsidized by government money and living only because they are subsidized. There is, however, one great organized transportation line in the United States, but it is owned and operated by the United States Government, and its very great losses, year by year, are paid by the taxpayers to the Federal Government. That is the U. S. Trans-Continental Air Mail, operating between New York and San Francisco every day. In effect, there is no difference between a private operation under subsidy and an operation for profit by the Government, with the deficits paid by the taxpayers. If the Government had chosen to establish the air mail in the first place by subsidizing private companies and guaranteeing them against loss, instead of operating the lines itself and meeting the losses, there would have been in this country at least this one great line and probably half a dozen others operating throughout the country on a basis exactly similar to the basis of the European lines. It was up to the Government to choose which way it would elect to spend its money. It is possible that it chose the wiser way and the less expensive way, for if private capital in this country had ever managed to get its feet into a trough full of subsidies, God knows how much of an appetite it might have developed by this time.

As it is, the era of organized private commercial flying in the United States has begun. There have been organized in this country within the past year about half a dozen substantial, well-capitalized and well-backed concerns to buy and operate ships for profit. Mr. Ford was the first in the air, operating a line of all metal ships from Detroit to Chicago, and later from Detroit to Cleveland, for the transportation of his own tonnage, and later for the transportation of mail. His operating experience is very freely offered to all other operators. His whole operation has been public-spirited and generous and was in fact the starting point of organized commercial aviation in this country. Later in the year 1925 the Colonial Air Lines was organized and soundly financed, to operate a line between New York and Boston. These people are starting on a broad, intelligent plan to develop organized traffic not only in that territory but also South from New York and possibly West from New York.

Another sound company was organized, financed and equipped to fly the air mail from Los Angeles to Salt Lake City, along a semi-desert route. It will start operations early in the Summer, confident of success and capable of achievement. It will also operate, I understand, from Los Angeles to San Francisco.

In the far West, another route will undertake to give service between San Francisco and the Northwest, Portland and Seattle, a difficult route over the Siskiyou Mountains.

Still another private enterprise, backed and operated by young men of intrepid spirit, will fly the mails from Pasco, Washington, to Elko, Nevada.

In the Middle-West an enterprising pilot, Mr. Robertson, of St. Louis, has organized and financed, and is now preparing equipment to fly, a mail route from St. Louis to Chicago.

Another private company, headed by Mr. Dickinson, will transport the mails between Chicago and Minneapolis.

A National Group

Early in the Spring of 1925, Mr. Howard Coffin and Mr. Edsel Ford, of Detroit, invited a group of capitalists, from New York, Chicago and Detroit, to meet with them at Detroit and organize a private enterprise to go into the operation of air lines, aiming chiefly at the great task of flying the long route between New York and Chicago, but willing to undertake other flying operations if and when it seemed wise. Mr. Ford later withdrew, because he desired to devote his attention to his own operations at Detroit instead of scattering his energy in several directions. The group, however, went ahead. It ultimately became a balanced triple group with most of its capital drawn from these three great cities—New York, Chicago and Detroit. How broad that group is, may be inferred from the fact that it contains a substantial cross-section of the younger banking and industrial world of Chicago; another balanced group of industrial leaders of Detroit; half a dozen well-known Wall Street capitalists, and the heads of the two largest aviation companies in the country—Wright and Curtiss. Philadelphia is also splendidly represented by Mr. Ludington and Mr. Pitcairn and their associates. These two young men, not only through their outstanding experience as pilots and operators but also through their willingness to work, have gained the respect and strong personal liking of the entire group. Since all enterprises need an active administrative head, this one chose as its general manager Col. Paul Henderson, formerly Second Assistant Postmaster General and the man more responsible than anyone else for the successful operation of the U. S. Air Mail.

No one interest controls, nor can control, more than five per cent of its stock, and its national character seems to be assured by the fact that its by-laws provide that in case of extensions into new country the residents of that section of the country may, if they please, participate in its financing on the same basis as the original stockholders. This company, with $2,000,000 of capital subscribed and $10,000,000 authorized, is now preparing to begin operations early in May on the long line from Dallas to Chicago, and expects to enter the New York-Chicago field within the year.

In addition to the above, there are half a dozen other organized transportation lines which are not preparing as yet to operate air mail routes, but which have undertaken steady operations from point to point. One of them is a Florida enterprise headed by Mr. Reed Chambers.

The above is a sketch of the first steps of this infant industry. It will be observed that, with the exception of Mr. Ford's enterprise, they are all preparing to operate rather than operating. To go back, then, to the heading of this speech, the present of commercial aviation in America, so far as organized lines are concerned, consists only of preparation. There are no figures to be furnished, either of tonnage, profits or losses. There is no accounting to be rendered of success or failure. The present of organized commercial operation consists of dreams that may come true, visions that may be realized, hopes that may blossom forth into realities, and courage that faces the future without fear. I might have said just those few words, and let my subject go at that, but I thought that some of the concrete steps that are being taken might well be of interest to you.

Let us admit, then, that so far as the present is concerned, Europe has organized commercial aviation, and the United States is going to have it.

Flying Service

From that point onward I deny, flatly, that in the United States we are inferior in commercial aviation to Europe. Let us turn to the second heading, which I have described as "Flying service." So far as I know, it has never been well analyzed, nor has it been fairly presented to the public. I will present it in general terms, hoping that within a little while the people of the United States will understand it and knowing that, if they do, they will not be ashamed of it.

There is in this country an enormous amout of air transportation that flows steadily and consistently all the time and that, in volume, in the measure of its service and in its usefulness to the country, compares favorably today and has compared favorably at all times, with commercial aviation in Europe. They make no report to the Interstate Commerce Commission nor to anyone else. They do not care much what equipment they use so long as it has a motor and a pair of wings and will fly. Nevertheless, they do fly.

There are in this country, the statisticians say, more than 2,000,000 trucks moving on the roads of the country. A very large number of them are engaged in interstate traffic, steadily, regularly, day after day, moving goods from point to point throughout the United States wherever there are goods to be moved and roads to move them on. They do not report, like a railway or a street railway, to any government official the amount of goods they move or the distances they move them, nor their individual revenues as trucks. Nevertheless, they are transportation and, if they could be presented as a whole with their ton-mile statistics and their earnings, they would in all probability constitute an industry with a net earning power of more than $200,000,000 per year and a capitalization, for equipment alone, in excess of a billion dollars.

In exactly the same way, there is an enormous amount of air transportation in the United States, of which there is no systematic record and at the volume of which one may only guess. Mr. Bradley, of the Aeronautical Chamber of Commerce, has begun to collect statistics from these people concerning 1925. He sent out letters to everybody of whom he had any record as owning and operating a plane. To date he tells me he has received reports from 177 of these operators, with many of the larger operators not heard from. It is certain that his preliminary report does not cover more than a quarter of the actual operators in the country. This sketchy report, so far as it has gone, however, will no doubt be interesting to you.

These 177 operators who have reported state that they have made a total of 133,467 flights, have flown 3,043,000 miles, have carried 145,927 passengers and 187,000 pounds of freight, and have a total of 444 machines engaged.

These official figures may be supplemented by an unofficial estimate made for the Curtiss Executive Committee a month or so ago, which listed 1,500 aeroplanes in the United States flying for hire. The Curtiss Company itself, through a small subsidiary company, has 21 ships in operation and earned, in 1925, a very fair rate of return on the capital involved.

On the Pacific Coast, there are six well-organized and locally well-known companies flying commercial planes and there are scores of individual operators flying for hire. I have met some of these people. None of them seems to be discontented and most of them are still ambitious. They make no returns to anybody except the Income Tax Collector, who is now beginning to learn to mind his own business and not become a disseminator of public news. One young gentleman told me last month that his income for 1925 was more than $20,000, and that his capital engaged in the business was less than $25,000.

It Is Working

In this great unorganized commercial aviation in the United States—standing on its own feet, self-supporting, unregulated, hopeful and cheerful—we have nothing of which to be ashamed and much of which to be proud. The pilots, while lacking knowledge, necessary in Europe, as to signals, control stations, landing field regulations and customs red tape, are not at all lacking in ability to steer a safe and straight course across country, to make safe landings, to handle their machines in emergencies, to get away in the night successfully, and, generally, to deliver the goods, literally and metaphorically—and that, after all, is the essence of commercial aviation. They do all sorts of things. In my own company, out of 2,265 flying hours, instruction constituted 580 hours, passenger carrying 354, photography 320, and cross country 366, and our own testing 155. Curiously enough, the income derived from passengers, instruction, and cross country flying was practically identical. In these 200,000 miles or so of flying for pay, more than 4,000 passengers were carried, 60 students were trained, and service was furnished to most of the large aerial photographic companies. We do not photograph ourselves. The largest part of the cross-country flying was for the newspapers who desire to place on the ground, for important events and especially for such sudden and unlooked-for events as the Shenandoah disaster, their crack reporters and photographers. The inauguration of President Coolidge kept about five of our machines and forty of other people's machines busy. Trips to the Kentucky Derby, Harvard-Yale football game and other important sporting events are quite common occurrences. At the time of the Shenandoah disaster, six of our planes flew more than 2,500 miles in two days. A salesman for a concern that manufactures lunch wagons flew to a convention in New Hampshire and sold ten wagons before his competitor arrived on the ground. That is what you call getting a "hop" on your competitor.

In the newspaper field, the airplane, in all parts of the United States, is now an essential, integral part of the news-gathering machine. It enters into the daily life and daily service of the people of the United States to an extent of which the public is not at all aware. This branch of the business alone, if it were organized in the United States, would, I believe, compare very favorably with the whole of Europe's commercial aviation as to volume and certainly would far surpass it as to earnings.

So much for commercial aviation as it now exists in the United States. I am not ashamed of it or do I despair of it, nor do I look upon it with the contempt of the casual writer who will not pay any attention to a commercial airplane unless it has a picture and a name painted on the bottom of its wings to indicate that it is a part of organized commercial flying.

In passing, and having nothing to do with this particular subject matter, I want to say publicly a few things about the two Air Services in Washington, and about the men who are the leaders in this aviation game and who have kept the Flag flying through the long, hard period that has passed and since the close of the war. I take off my hat in respect to the courage and patience of the officers of the Army and the Navy who have conducted the administration of both the Army Air Service and the Naval Air Service throughout this period. Neither of these groups, until very recently, had any material backing or support from the great Boards of officers which control the Army and the Navy respectively. The General Staff of the Army and the General Board of the Navy, actuated no doubt by their sincere belief that the general good of the Army and Navy demanded it, have sought to repress rather than encourage the growth of aviation in these Services, to minimize the importance of the aviation branches and to discourage their growth. In spite of this great handicap the Air Service officers have pushed forward. They have not done half the things that they would have liked to do, but the things that they have done have been done well and honestly. At the present time, happily, there is a growth of knowledge and sympathy for aviation, both in the General Staff and on the General Board, and these aviation officers, having fought a great fight, against long odds and for a long period, for what they believe to be right, now seem to feel that they will be able to keep the United States in her proper place among the air-minded nations of the world.

The Future

Now let me touch briefly upon the future. Before doing so, I want to say that I am not a prophet nor the son of a prophet. I am only a business man, interested in all branches of the flying industry. My best friends do not accuse me of being an optimist, and I am not particularly optimistic about aviation. There are, in fact, very few of the aeroplane manufacturers who have had any opportunity during the past six or seven years to cultivate the virtue of optimism.

The little handful of aviation leaders, like Glenn Martin, 'Loening, Vought, Douglas, Boeing, Huff-Daland and others, have all at different times fought against loss, discouragement and oppression. At different times throughout this period it has been just about a toss-up with each one of us whether we should go on or not. More than half of the leaders of aviation in 1918 were forced out, or voluntarily got out, during the past six years. Those who have remained needed to be men of courage, hope and vision, and I can say for these gentlemen that none of them are lacking in those virtues. The people of the United States have reason to be proud of the character, courage and ability of the handful of men who have survived in this hard-driven little industry.

These men, as the future of commercial aviation expands, will go forward with it. They will be responsible for the character of the equipment, for the element of safety in flight, and upon them will rest the confidence of the public, without which no commercial industry can exist. If on this alone rested the future of commercial aviation, there would be no doubt about the answer, for there is no group of manufacturers in the world who put more character, more integrity and more honesty of purpose into the machines which they produce than these American manufacturers.

Now I want to give you a little bit of analysis to think about. Get your minds fixed for a moment on 1,000 pounds of something or other that needs to be carried from some place to some place. That is a half-ton load. It is a full load for a half-ton truck, costing about $1,000. It is a full load for a commercial aeroplane, costing about $25,000. The half-ton truck will run steadily every day for about three years, with mighty little maintenance except tires and will haul that 1,000-pound load at a total cost not exceeding $5.00 per 100 miles, including depreciation. The aeroplane will run 2,000 miles with somewhere around two changes of motor, but the total cost per mile, including depreciation, will be approximately $1 to $1.50, depending upon whether the country over which it is to fly is open country that can be flown with one motor, or difficult mountain country, such as the New York-Cleveland flight, which must involve the use of multi-motored ships. The cost per ton per mile, therefore, of transportation by aeroplane is approximately 20 to 30 times the cost per ton per mile by half-ton truck. The average cost per ton per mile for freight on the Pennsylvania Railroad in 1924 was about 1 cent. The basic aeroplane cost will be, therefore, approximately 200-300 times the cost per ton per mile for freight on the Pennsylvania Railroad.

There you have the future of commercial aviation—if it has one. Needless to remark, I am not putting any money into the business of trying to carry freight in competition with the Pennsylvania Railroad on that basis, nor am I putting any money into the business of trying to carry freight in competition with the half-ton truck.

Here is the question which must be answered; and there is only one source from which the answer must come. The question is, whether the people of the United States want to pay something over $2,000 per ton for the transportation of some commodity or other, for instance, between New York and Chicago, in sufficient volume to justify anybody putting into schedule operation on that line one, two or more aeroplanes for the purpose of carrying on that transportation.

That tonnage is not today in sight. The rate is far in excess of the first-class express rate—it is far in excess of any other rate known to commerce. The elements that would make any form of transportation worth that much money are not ordinary commercial elements; they have to grow out of new requirements and new necessities. The thing which the shipper will pay for, of course, is speed. If a package or a letter can leave New York at 8 o'clock tonight and be in Dallas, Texas, by 8 o'clock tomorrow night, the transportation of that package or letter is a commercial thing that can be sold at some price. That price has to equal the cost of giving the service plus a fair profit, or else the service will fail.

Two years from next October we may be able to give you the answer. At the present time we can not. We know that there will be a certain amount of mail moving on these lines. We know that the rate established under the Kelly Bill, viz., 80% of the full postal rate, will pay these costs and yield a reasonable profit, providing the amount of tonnage is sufficient, but we have no idea at the present time what that volume of tonnage will be. So that even this part of the problem is a mere estimate.

Let us take the best view of it. That best view is that there will be a sufficient volume of mail and of a package express capable of paying these rates, and of bank papers and securities in the transportation of which the saving of interest is of great moment, to make these services pay.

In that case, two years from now there will have been established in the United States a transportation system by air that will be, as it were, the main line of air transportation. It will be self-supporting, unsubsidized, publicly owned and free. From the moment it is established that the thing can be done, its growth will no doubt be extraordinary; just as the growth of all transportation systems in the United States has been extraordinary throughout the whole history of the country. Instead of running only between main line cities, it will reach out into all the corners of the land, for in this country no city can afford not to use the fastest and most modern proven means of transportation. If, therefore, in these next two critical years private capital demonstrates that the people of the United States want this transportation at the cost which it incurs, we, who are pioneers in this branch of transportation will be proud and happy to have taken part in the accomplishment of this great task.

If, on the contrary, tonnage does not develop, service is haphazard and inefficient, and the people of the country do not want to pay enough for this service to keep it going, the result is fairly obvious, and it is not necessary to detail what that result will be. I believe there is not a single stockholder in the National Air Transport, for instance, who does not understand clearly the task we are trying to do and who does not see exactly what the result will be either way. We are not blind enthusiasts. The entire experience of the Wright Company, the Curtiss Company, and of operators like Ludington and Pitcairn, sits on the Executive Committee of the National Air Transport. We go cautiously, not recklessly, fully expecting to turn our dreams into realities and to succeed, and not to fail.

"Airways and Airdromes"

By COL. PAUL HENDERSON,

General Manager of the National Air Transport, Inc.

I WAS very glad indeed that Mr. Keys put that little note of optimism that he did in those last few remarks. He had me almost crying, thinking of the problems, with no good news in them, that were ahead of me; but I am going to take encouragement from his last few words.

Describing airways and landing fields and airdromes is a good deal like describing a parade, when each section is different and only passes one point once. This whole art of flying is in such a state of flux, and so much in its kindergarten stage, that things we may think about today very enthusiastically, ideas we may congratulate ourselves on having, may, by tomorrow, seem to be crude and foolish and silly. Therefore, what I can tell you about airways and airdromes and landing fields and so forth as of today, by the day after tomorrow may be, and probably will be, old fashioned. It is only because of that progress that we can look forward with the optimism that Mr. Keys finally expressed as to the whole situation. I will attempt to tell you a little bit about airways as we know them and see them today; and I will do just a little guessing as to the future. It will have to be absolute, plain guessing—because nobody knows.

What Is an Airway?

In the first place, I believe the average layman thinks of an airway as that path in the air between two certain points. As a matter of fact, an airway is just as truly on the surface of the earth as is a railway or highway or navigable water. I think of an airway, and would like to have you think of it, primarily, as being that part of the air flown through between two certain terminals together with the ground beneath it. In the airway between Chicago and New York, for example, I do not think the terminal landing fields or the airdromes in either terminal, Chicago or New York, are any part of the airway, any more than the harbor of New York is part of the channel through which the ocean-going vessels ply. The airdromes and terminals are one thing and the airways are another thing. When we first undertook to fly, all we concerned ourselves about were the terminal fields; we let the pilot worry about the other part. If the country was rough and mountainous, he had something to worry about, too. If it was smooth, with all open fields, he had little to worry about. But the reason he did have to worry, in either case, is that airplanes do not always stay up in the air. If they did, we would not need airways and then the idea of an airway being altogether in the air would be a good one. But they do not always stay up in the air and there must be something to come down on and come down on safely. I don't think we had an appreciation of what an airway meant until we made studies as to what we would have to do to fly at night. We knew the boys were rather successful in coming down during the day on fields that had no preparation; our most serious trouble was in settling with the farmer for spoiling the corn crop or mutilating his grain. But during the night one cannot see the ground as distinctly as during the day and we found we must make some definite preparation for landing between the terminal fields.

Emergency Landing Fields

We started out with the idea that we needed emergency landing fields every twenty-five miles and that is still almost the standard. We felt they should be about forty acres in size and most of them are of that size now. We found we must provide runways—open runways of about a thousand to fifteen hundred feet. An ordinary airplane will come to rest on the ground in something less than a thousand feet and will take off into the air in about a thousand or a little over a thousand feet. Then, on these emergency landing fields, we put revolving beacon lights, but the solution was reached only after probably as much trouble as with anything else. We didn't know just what sort of light to put there. We first thought of putting a cone up and making it as brilliantly lighted as possible. We took a water tank, out in Iowa, and did that but we found it did not work at all; the pilots could not see it far enough away. Then we tried searchlights with beams going directly into the air and, on a night a little cloudy or hazy, that worked nicely; the beam could be seen for quite a distance.

But on a clear night it was impossible to see it at all; it was shining on nothing but air.

One night I happened to be down in central Illinois waiting, with a friend, for a train to go to Chicago. It was about midnight. After a while, I saw the light of the train coming into view and started for my luggage. My friend said there was no hurry, that the train was still twenty-five miles away. And I found I was looking twenty-five miles down a straight track into the headlight of the locomotive. Right there we solved our problem of the beacons. We set the searchlight so that its beam would go almost parallel with the horizon and turned it five or six times a minute. Thus the pilot, wherever he may be in that zone, will get this flash in his eye. We laid out our emergency fields at intervals of twenty-five miles; put a revolving searchlight on top of a windmill tower, always in the same corner geographically; then put an electric, acetylene or gasoline lamp to indicate the four corners of the field, removed obstructions, like high trees; and called it a job.

In Between

In clear weather, a pilot would see three or four of these revolving searchlights but, in thick weather, he would have difficulty in seeing from one field to another. So we put acetylene lights along the route; and there we made our first blunder. Such lights were placed along the entire route from Chicago to Cleveland in an absolutely straight line; in fact, we sent a surveyor over the route first and, no matter where the path came, at three-mile intervals on a straight line between these two cities, we put our lights. We found we had made a mistake. We moved the lights and put them on approximately a straight line but, sometimes, as much as a mile or a mile and a half off the straight line and each one on a landing field of one kind or another, the best available in that immediate vicinity. So that now, in the air mail—I cannot think myself as being absolutely out of the employ of the Government, for I still say "we"—we have landing fields, forty acres in extent, with revolving searchlights, at twenty-five-mile intervals and, at three-mile intervals, we have what you might call third-rate landing fields, where the pilot will be able to land without serious difficulty. That is the airway of today. Of course, the terminal fields are more brilliantly lighted, having lights, of a billion candle power, and may be seen a little further. Buildings also have to be lighted. But that is, in general terms, the airway of today.

I don't think for a minute that that will be the airway of tomorrow. In the first place, even these lights, of which we were so proud a few months ago, are already beginning to seem less important because we are learning that radio will permit us to navigate, later on, without any lights at all. The Army and Navy point to this as the ultimate method. I believe it is entirely feasible by directional radio to inform the pilot where he is, literally within perhaps two miles variation, over a distance of two hundred miles. An air mail test installation put in at Monmouth, Illinois, consists of directed radio waves which grow wider as they go away from their source until, at the end, they are seven miles wide. The pilot gets a certain code signal in the air; two dashes mean, "in the center"; "to the left," two dashes and a dot; "to the right," a dot and dash. That is practical and it is our hope that, within a few months, there will be an installation of directional radio in actual operation on at least one of the airways of the United States. So we will learn more about it and, as it develops, the importance of lights will diminish. If it develops to one hundred per cent efficiency, we will need no lights in the future. We will have to have emergency landing fields, of course, and a certain measure of light on those fields, although General Brancker tells me that in Europe they are having marked success with electrically-charged cables underground, to lead the pilots in a fog not merely to the field but, in addition, to a certain spot in the field. We haven't got that but we are watching General Brancker's work very carefully.

Whose Job Is It?

Besides the physical job of the airways there is the rather practical political job. Whose job is it to furnish airways? Two years ago that was a much discussed and very little understood subject. Nobody had any fixed ideas on it. I think within eight or nine months the ideas of the country have crystallized on the subject. I think there is a very definite realization that airways between terminals are a federal responsibility, that terminal landing fields are a municipal responsibility. Take the company I happen to be managing. We would be delighted to build an airway and furnish ourselves with terminal fields in Chicago and New York—do everything necessary to provide ourselves with that facility if anybody could give us an exclusive right to operate over it; but nobody could. Nobody could say we might operate over it and John Smith might not.

So airways cannot develop as railways did. The pioneer who built a railway was at least certain it would be his locomotives and rolling stock that would run over that railway. We have no such assurance. So it seems we have to go to the sea for our parallel. I think the Federal Government's responsibility to navigators of the air is exactly the same as its responsibility to navigators of the sea and, of course, if the Federal Government has a responsibility toward us, we have a responsibility toward it. If it provides us with airways, properly controlled and equipped with radio, we must in turn fly over those airways in airplanes that are worthy, and with pilots properly trained. I think, within the next ninety days, legislation will be passed that will enable the Government to have actual Federal airways in the United States, laid down and maintained and operated by the Federal Government for the joint use of all who will operate over them properly and under regulations that will be prescribed.

The municipal responsibility for landing fields, it seems to me, is just as definite as the Federal responsibility for airways. For example, suppose Mr. Ludington, who operates airplanes here, should buy himself a landing field and equip it and fix it for his own use. He could not prohibit others from using it; could not shoot them for landing on it. He might chase them off afterward but they would have been there. You do not want to make a railway station affair out of the landing field but a community affair. It seems to me the municipal responsibility for the landing field is as great as the federal responsibility for the airways. Airplanes travel so fast that the States do not as a rule get into the picture. That others agree with me in this is borne out by the fact that the National Air Transport has been provided with municipal fields by the cities of Moline, St. Joseph, Kansas City, Wichita, Oklahoma City, Fort Worth and Dallas. In some instances, the field does not belong to the municipality but has been provided by the Chamber of Commerce or some other civic organization (because of the lack, at the moment, of local laws permitting the municipality to provide such a field) yet it has been a civic donation in each case.

Your own city has, in this way, provided a landing field. Cleveland has provided one; and Chicago has invested twenty-five thousand dollars. New York is trying to provide itself with a landing field but the field ought to be in New Jersey, and it is difficult to get New Yorkers to spend money for New Jersey. Boston, I think, was the third city to have an honest-to goodness Air Port. I think there is a combination of the Municipality and the State. In Pittsburgh, the County (Allegheny County), and the Municipality of Pittsburgh, have clubbed together in some way and provided themselves with a landing field.

Mr. Keys spoke of the military value of commercial aviation. I think there is a military value to all we are trying to do and I think there is a very definite military value in airways. For example, when the Government has provided itself with five or six thousand miles of lighted airways throughout the United States, over which airplanes can fly at night as well as during the day time, it will be of definite value. There may be a time when Captain Steele will want to go quickly from New York to San Francisco; the airway will be equipped with lights and radio and telephones, and his trip will be made as safely as on a railroad.

(Record of meeting will be continued in June issue.)

Highway Engineering

Resume of Proceedings Fifth Annual Meeting Highway Research Board—National Research Council

Prepared by JULIUS ADLER, Consulting Engineer

THE Fifth Annual Meeting of the Board was held at Washington, D. C., on December 3 and 4, 1925. Charles M. Upham, Director, called attention to the growth of this organization, which now has active contact men in 44 state highway departments and 121 universities; as well as contacts with Latin American countries. He pointed out that in addition to its Research Committees, the Board now has under way four special investigations financed by industrial concerns, and headed by paid chairmen who, in most cases, give their entire time to the work. These investigations are: A study of the economic value of reinforcement in concrete roads; an earth road investigation; a culvert investigation; and an urban highway finance investigation. Reports were received not only upon these subjects, but also upon investigations covering the economic theory of highway improvement; structural design of roads; character and use of road materials; highway traffic analysis and maintenance of roads.

The reports upon some of these subjects show that the investigations have not passed the preliminary stage, but all represent valuable contributions to present knowledge in their respective fields. From these several committee reports, the following, representing those of more general interest, have been selected for complete or partial reproduction:

REPORT OF COMMITTEE ON ECONOMIC THEORY OF HIGHWAY IMPROVEMENT

Chairman, T. R. Agg, Iowa State College

Relation of tire tread wear to type and condition of road surface. The investigations on this subject show the following preliminary results:

Tire wear indices for various road surfaces.

Road Surface	Index Number
P. C. concrete	1.00
Monolithic brick	1.01
Bituminous filled brick	1.00
Iowa gravel	2.20
Chert gravel	7.30
Bituminous macadam without seal coat	10.60

Other investigations show that the rate of tire wear on macadam is 17 times as great as on concrete, and may be 56 times as great on poor macadam.

Riding qualities of road surfaces, rolling resistance and gasoline consumption on typical highways are being studied, but these projects are not in the stage where results are available.

REPORT OF COMMITTEE ON STRUCTURAL DESIGN OF ROADS

Chairman, A. T. Goldbeck, formerly with U. S. Bureau of Public Roads

Subgrade Investigations.—The most unfavorable subgrade conditions are due to excess moisture in soils that are affected thereby. Such excess moisture results from (a) poor surface drainage, and (b) poor internal drainage.

Under the most favorable climatic conditions few failures are due to the subgrade. Favorable climates involve moderate temperatures with comparatively low precipitation, and particularly low precipitation during the winter months. Unfavorable climates have long continued periods of cold weather; high precipitation during freezing weather; or frequent alternations of freezing and thawing combined with deep freezing.

Additional information on admixtures for subgrades is included in the report.

Stresses in Concrete Road Slabs.—Tests indicate that concrete, when reinforced with small amounts of steel, may be extended more without visible cracking than when unreinforced.

The extensibility of dry concrete beams was found to be less than that of wet specimens.

Deformation measurements in existing concrete roads furnish an excellent index of the load-carrying ability of the slab. The recent measurements corroborate the thickened edge design. Tests in Cook County, Illinois, indicate that a 9-7-9 section is suitable for an 8,750-pound maximum wheel load..

It is indicated that, for all practical purposes, the stress produced in concrete pavements is directly proportional to the wheel load.

Within practical minimum limits of axle spacing, the individual axle loads of a six-wheel truck may be as heavy as in the case of a four-wheel truck.

REPORT OF COMMITTEE ON CHARACTER AND USE OF ROAD MATERIALS

Chairman, H. S. Mattimore, Pennsylvania State Highway Department

High Alumina Cement.—High alumina cements are reported to be resistant to acid and alkali waters. The strength of this class of cement at 24 hours is equivalent to that of Portland cement at 28 days, but its behavior in long-time tests is not definitely known.

While the cost of high alumina is from two to three times that of Portland cement, it has been successfully used on special construction.

Accelerators in Portland Cement Concrete.—The various investigations reviewed in this report indicate that calcium chloride and compounds with a calcium chloride base may perform the useful function of accelerating the hardening of concrete. The rate of acceleration for the compounds commonly used is in a direct relation to the calcium chloride content.

The principal advantage of these accelerators is the securing of early high strength. This results in the earlier possible use of the structure and in protection against adverse curing conditions.

REPORT OF COMMITTEE ON HIGHWAY TRAFFIC ANALYSIS

Chairman, G. E. Hamlin, Connecticut State Highway Commission

The Three-Lane Two-Way Roadway.—A three-lane two-way roadway is one upon which the traffic movements are in both directions, and which is only wide enough for three moving vehicles to be abreast.

The actual traffic capacity of a two-lane roadway varies within wide limits. It is evident that a three-lane roadway will permit vehicles to pass each other with a greater frequency than on a two-lane road. The three-lane roadway, however, provides conditions under which accidents may frequently occur. The Committee recommends the use of a four-lane roadway when the capacity of the two-lane roadway is exceeded.

Highway Traffic.—Transportation surveys indicate a close relationship between population per square mile, the trend of population, growth and industrial development, and the amount of traffic using the highways.

The prediction of expected future traffic based on the projection of the trend of motor vehicle registration is a reasonably accurate measure of future highway traffic.

Elimination of Obstacles Impeding the Free Flow of Traffic.—The movement of traffic over any route depends upon its ability to move freely at all points.

The Committee believes that the elimination of obstacles to traffic on many highway routes will be justified by the increase in the safe movement of traffic; and in some cases, the program of widening can be economically deferred by this method.

The Committee recommends, in the construction program for highway improvement, that there shall be seriously considered the planning for arterial highways outside the congested areas.

The Committee is of the opinion that, in many cases, the installation of a fixed signal supported by a pedestal at the intersection of highways is not justified.

Adequate Rights-of-Way.—The Committee recommends the following:

1. Determination of present right-of-way.
2. A highway transport survey to determine necessary required widths.
3. Acquisition of additional necessary width.
4. Simplification of method of acquisition to permit immediate occupancy.

INVESTIGATION OF URBAN ASPECTS OF THE HIGHWAY FINANCE PROBLEM

Jacob Viner, University of Chicago

As this research is still under way, the findings are tentative. On many important points the absence of the necessary statistical data limits research to discovery of the problems rather than of the means to their solution.

The Contribution of Urban Dwellers to the Financing of Rural Highways.—The contribution by urban automobile owners of a large fraction of the state motor vehicle tax revenues, the expenditure of these revenues upon the construction and maintenance of rural highways, and the absence of state contributions to the cost of construction and maintenance of urban streets, appear to involve an injustice to urban automobile owners. The problem, however, is not as serious as it appears, since traffic tests indicate that the bulk of the traffic on rural highways is urban traffic. Nevertheless, some participation of cities in the revenues from state motor vehicle taxes seems just.

Financing City Streets.—The space occupied by city streets would be needed, even in the absence of surface transportation, for purposes of access to air and sunlight, and for city ornamentation. Some proportion of the cost of pavements is properly to be charged to street railways, horse-drawn vehicles and pedestrian traffic. The bulk of the cost is now borne by real estate. Urban motor vehicle and tax revenues provide but a negligible percentage of these costs. The case for and against a transfer of a more substantial part of this cost from real estate to motor vehicle owners is being investigated.

Financial Aspects of Urban Traffic Control Problem.—The increasing financial burden on cities providing facilities for growing automobile traffic, requires co-ordination of traffic control policies with construction and maintenance program. Traffic congestion is an automatic but wasteful mode of traffic restriction, and it will be necessary to devise programs of restrictions in congested areas which will prevent undue congestion by restricting traffic at peak periods to economically efficient carriers. Current comparisons of efficiency in passenger transportation on basis of road-space-displacement per seated passenger are inadequate. Road-space-displacement per actual passenger-mile is a better formula. The possibility of economic control of traffic through the development of fees based on use of road space at peak periods is being considered.

SUMMARY OF CONCLUSIONS OF REPORT INVESTIGATION OF THE ECONOMIC VALUE OF REINFORCEMENT IN CONCRETE ROADS

C. A. Hogentogler, Highway Research Board

1. The amount of cracking and subsequent disintegrating is a function of time; thus, the rate of cracking is a measure of the life of the pavement.
2. The data show that steel reinforcement reduced the rate of cracking and thus increased the life of the pavement. This applies both to concrete pavements and other pavements laid upon a concrete base.
3. Crack reduction is more economically accomplished by the use of steel reinforcement than by additional thickness of concrete.
4. A greater reduction was afforded by small steel members closely spaced than by larger members wider spaced.
5. Increasing weight of mesh from 25 to 56 lbs. per 100 sq. ft. considerably reduced cracking.
6. Mesh reinforcement, 25 to 56 lbs. per 100 sq. ft., reduced cracks 35 to 70% in pavements of like thickness.
7. Mesh reinforcement, 25 to 56 lbs. per 100 sq. ft., and bar mat reinforcement 64 pounds per 100 sq. ft.—25% longitudinal—reduced cracks more than one additional inch of concrete, but one additional inch of concrete reduced cracks more than bars (42 to 48 lbs. per sq. ft.) placed transversely only.
8. With good crushed stone aggregate, 56 lbs. per 100 sq. ft. mesh reinforcement, or 170 lbs. per 100 sq. ft. bar reinforcement, 50% each way, caused a reduction in combined transverse and longitudinal cracks equal to that indicated for 2 inches additional center thickness.
9. Mesh reinforcement of 38 lbs. per 100 sq. ft. has been effective for a thin layer of concrete laid as resurfacing upon an old concrete road.
10. One additional inch of edge thickness reduced corner cracks more than mesh reinforcements 25 to 56 lbs. per 100 sq. ft., or ⅜ to ¾ inch bar reinforcement, but progressive destruction following the appearance of corner cracks was arrested by steel reinforcement.
11. All types of steel reinforcement across cracks tended to hold together fractured slabs.
12. Bar reinforcement across transverse joint, without proper provision for slippage and clearance, resulted in breakage and subsequent expensive repairs.
13. For long slabs, 75 to 100 feet or over, edge bar reinforcement with continuous bond caused corner cracks if the area of steel exceeded ¼ sq. inch.
14. A remarkable agreement was found to exist between results of observations on roads in service and results furnished by a wide range of experimental roads and laboratory tests.

A complete report of the Proceedings of the Fifth Annual Meeting (available about April 15) may be secured by addressing, Highway Research Board, National Research Council, Washington, D. C.

Electric Shovel Efficient

Increased output in a shorter period of time, together with a reduction in labor, resulted from the installation of an electric shovel by the Cowell Portland Cement Company at Cowell, California. It was found that six cars could be loaded with the electric shovel while the steam shovel was loading five. The operator of the steam shovel was an experienced man, while the electric shovel was operated by a steam operator who had had no previous experience with electrical equipment. The dipper on the steam shovel had a capacity of three cubic yards, while the electric shovel had a dipper of but 1¾ cubic yards capacity.

Power is supplied from a 2300-volt transmission line running from the mill substation to the quarry where, by means of transformers, the voltage is stepped down to 440 and converted into direct current by the motor generator on the shovel.

In operating the steam shovel, nine men were required, a shovel runner, a craneman, a fireman and six pit men. Only three men were needed for the electric shovel, an operator and two pit men.

There being no boiler required for the electric shovel, the replacement of tubes, and trouble from leaks, scaling, etc., were eliminated. A further saving was effected by the elimination of a night watchman for keeping the boilers fired at night. Approximately three-fourths of the time necessary to move from one location to the next is saved by the electric shovel, as temporary roadbeds and tracks are unnecessary.

Highest Heat Yet Recorded

Manufactured gas and oxygen, properly combined and used, give the highest temperature thus far produced by man. The University of Leeds, England, reports that a temperature of 7,677 degrees Fahrenheit was reached in an experiment made there recently.

ENGINEERS & ENGINEERING

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The Business Situation

AS there has been no general commodity price inflation, with no increase in merchandise inventories, there is little or no probability of a drastic break in prices. However, the over-selling of automobiles by forced partial payment methods, thus cutting into the future market and helping to accumulate large numbers of used but still serviceable cars creates a dangerous situation. The result is a credit and used-car situation which may cause a sudden reversal with the motor companies and accentuate sharply any decline in the price level of commodities in general.

Colonel Leonard P. Ayres writes in the *Cleveland Trust Co.'s Business Bulletin:* "Business during the first third of the year has gone forward in large volume and with good profits in many lines, and has been of record-breaking proportions in some of the most important ones. In the three key industries, automobile production, building construction, and iron and steel, outputs have been greater than during the opening months of any previous year.

"Among financial developments one outstanding event was the rather unlooked for action of the Federal Reserve Bank of New York in lowering its rediscount rate late in April, only three months after it had raised it in January. It has probably had little important effect in aiding commercial or industrial enterprise.

"It now seems probable that the first third of 1926 will prove to have been its busiest third. But commodity prices continue to decline, and this is having a depressing effect on business and on business sentiment. Something of a slowing down in iron and steel is in process, and a restriction of the rate of automobile manufacture during the later months of the year appears highly probable. Building construction may be stimulated by still more speculative work undertaken because of the great ease of money rates, but it now seems doubtful if it can continue to exceed each month the records of the corresponding month of last year."

The Guaranty Trust Company of New York, in the last issue of "The Guaranty Survey," finds: "The moderate decline in domestic trade and industrial activity has continued in recent weeks. The most conspicuous instances of this tendency in basic industrial operations are in iron and steel, building and automobiles. Certain branches of textile manufacture also have failed to maintain the pace of early spring.

"In wholesale and retail distribution the trend has been rather irregular. Retail trade has suffered severely in some sections from cold and stormy weather. Trade at wholesale has continued largely on a hand-to-mouth basis, this feature being emphasized by the rather consistent decline in commodity price levels during the last few months and the natural unwillingness of buyers to make forward commitments in falling markets.

Current Recession Not Severe

"The downward movement of activity, however, while distinctly visible, is by no means alarming. It is evident that no general depression exists, and present conditions fully warrant the belief that none is in prospect. In the vast majority of industrial and commercial lines the present rate of activity compares favorably with that of a year ago. It is doubtful whether the current recession is, on the whole, any more pronounced than the similar movement in the spring of 1925. A comparison indeed seems to indicate that business in general registers above the 1925 level.

"The financial situation remains highly reassuring. Further decreases in the volume of loans for speculative purposes have been reflected in money rates. The present level of rates on commercial loans is barely ¼ per cent above that of a year ago, and is lower than the peak of last October by about the same margin. In the third week of May the rate on prime commercial paper in New York declined to the unusually low level of 3¾ per cent. This compares with the rate of 4 per cent which had prevailed for some time.

"With a continuance of easy money and normal crops, and provided of course that peace prevails in Europe, the outlook is for reasonably prosperous business conditions for the balance of the year.

Declines in Industrial Output

"After a steady but not exceptionally rapid decline of several weeks' duration, activity in the iron and steel industry has become stabilized, for the time being at least, at about 80 per cent of capacity. Last month's operations represented about 88 per cent, with an average output of 158,613 tons a day. This compares with 166,236 tons in March (the record for the industry) and 137,834 tons in April, 1925. Evidently, therefore, the decline in activity has been by no means severe. That the rate of operations last month was still in excess of demand was shown by the decrease in unfilled orders reported by the United States Steel Corporation."

The National City Bank of New York, in its letter of June 1st, is more optimistic than some other authorities. It finds that: "Trade and industry continued at high levels throughout the month of May and, while some uncertainty prevails as to the probable trend in the last half of the year, no tangible justification for pessimism has yet appeared. Not everyone is satisfied with the volume or the profitableness of his business, but some of these complaints have to be discounted, as it has been shown time and time again that even in the best of years there is always someone who either is not, or thinks he is not, getting as much business as the rest. It is true that not all lines are showing as uniform improvement as was the case a few months ago, and some industries give definite signs that production has run ahead of consumption. Already this has necessitated some slowing up in various lines, and doubtless further readjustment may occur before the balance is everywhere restored. Buying however, has been generally conservative, and in view of the absence in most quarters of burdensome stocks and the promise of continued ease in money, there seems no reason why whatever further readjustment is needed should not take place without undue disturbance. The way in which the Florida boom has quietly flattened out without serious consequences is a reassuring demonstration of the influence of an easy credit situation in facilitating orderly liquidation."

R. G. Dun & Co. call attention to the "reversal of form" in our export and import business. As to business, they say: "The general situation seems to reflect a policy of conservatism rather than any serious contraction in the volume of business."

Building Construction

According to F. W. Dodge Corporation, building contracts in 37 states east of the Rockies, awarded so far in 1926, compare with 1925 as follows:

	1925	1926	Percentage of Change 1925-1926
January .....$	309,470,900 $	457,158,600	48%
February ...	310,882,600	389,899,800	25%
March	491,010,600	597,879,300	22%
April	567,567,000	570,613,576	½%
Total .....$	1,678,931,100 $	2,015,551,276	

The regular and marked decline in the rate of increase over last year is very striking, but the amount of contracts already awarded for 1926 will prevent any serious slump in this industry.

Exports and Imports

The decline in our exports of grain is a matter of no great concern, since our own supply of wheat is at the moment exceptionally small, and the smaller European imports are undoubtedly a reflection of the good European harvests during the last crop year. The extremely low takings of cotton offer, however, grounds for more serious consideration, since they reflect the slackness of economic activity in Europe. In any case, although we are expanding our exports to other continents, notably Asia and South America, the prosperity of our agriculture and, in consequence. that of the entire country is still intimately connected with the economic rehabilitation of Europe.

Particular attention is called to the pronounced decline in the proportion of exports to Europe as compared with the period immediately preceding the war. This decline is a reflection of the relatively smaller purchasing power of European countries which is due in part to the curtailment of their own exports. British shipments at present are only about three-fourths as great in volume as before the war, and those of Germany show a much greater decline; while the exports of the United States have shown a quantitative increase of about 30 per cent between 1913 and 1925.

So, although we may pride ourselves upon the fact that our foreign trade in general and our exports in particular have waxed in both value and bulk since the war, whereas, those of the leading countries of Europe are still behind the prewar totals, we must recognize that there is something untenable in the situation which calls for readjustment. The readjustment will undoubtedly be made through the continuance of the constructive financial and economic programs now under way in Europe.

Items of Interest

Economical Electric Well Drilling Rig

Savings in operating expense of more than 75% over steam operation, together with a number of other advantages, resulted from a change-over from steam to electricity in drilling water wells in the Tulare Lake district of California. In this district the water question has always been a vital one, it being necessary now to drill wells approximately 2,000 feet deep to find a source of supply.

Rotary rigs are used to drill the wells. With an electric oil well pumping outfit speed variations from approximately 1200 r. p. m. down to 300 r. p. m. on the motor are obtained. The equipment, together with speed reduction gears, was mounted on two heavy timbers (12" by 12") forming a sled which is easily moved with a tractor from one location to another.

With steam power it cost between $350 to $450 for fuel oil to put a well down 2,000 feet while the power bill for electric drilling has averaged approximately $90 per well. With the steam outfit it took approximately two weeks to move and set up ready to drill, while, with the electric equipment, but three days are needed to move and set up ready to drill. Furthermore, the time of drilling has been reduced approximately 50% with the electric rig.

New Handbook for Wire Rope Users

How to measure wire rope—how to and how not to uncoil or unreel wire rope—how to make an endless splice—how to properly seize rope—how to correctly socket wire rope—how to care for wire rope when both in and out of service, are just a few of the things told in the new 88-page handbook on wire rope recently issued by the American Cable Company.

In addition to such information, there is shown by detailed drawings, the best methods for making equalizing slings, bridle slings, and other miscellaneous sling and fitting equipment. There also appear brief, though complete, treatises on wire rope lubrication, the effect of heat on wire rope performance, alignment, reverse bends, fleet angle, idle ropes, and other such subjects. It covers in ample informative way every phase of wire rope usage, application and maintenance. Not only does it give detailed information regarding the various "lays" and the varying constructions of wire rope, but much data that should prove invaluable to wire rope users.

A copy of this handbook is to be had by addressing the publishers of this magazine.

DEPARTMENT OF COMMERCE
DIVISION OF SIMPLIFIED PRACTICE
Washington

Survey of Progress in Waste Elimination

Extent of progress in waste elimination during the last five years will be the topic to be considered by meetings forming a program of "Management Week," to be held in over 100 leading commercial and industrial centers during the last week in October.

It is the hope that interest may be focussed on the gains in efficiency of management which have followed such surveys of wastes in commerce and industry as: "Waste in Industry," made by the Hoover Committee on Elimination of Waste in Industry; the Committee on "Business Cycles and Unemployment," and the National Distribution Conference.

Each of these reports have made specific recommendations as to methods of curbing wastes and stabilizing business. Their findings have resulted, in many cases, by co-operative action by commercial and industrial groups, and by communities, in meeting problems and overcoming conditions as revealed.

As yet, however, no concerted effort has been made to discover the extent of benefits accruing from these attacks on waste, and it was this fact which led to the selection for the 1926 meetings of a topic which would permit of such a survey.

NATIONAL INDUSTRIAL CONFERENCE BOARD, INC.

Professional Immigrants

The proportion of immigrants belonging to the professional classes, which in the last few years before the war showed a tendency to decline, since 1920 has increased and, for the fiscal year 1924-25, was approximately three times as large as the average for 1910-14. This reflects the economic hardships undergone, during post-war years in Europe, principally by those engaged in cultural activities, as teachers, students and academicians of all kinds, artists, musicians and writers, constituting a large portion of the educated middle classes whose incomes and investments suffered severely through post-war economic adjustments. These professional people generally come to stay, resembling therein the agricultural immigrants and skilled workers, in contrast to the immigrants classed as common labor who, to a large extent after a few years, return to their home countries in numbers often in excess of those of new arrivals, as they did in 1911, 1912, 1920, 1922 and 1925. Out of 62,124 professional aliens, who came to the United States during the fiscal years of 1910 to 1914, 50,107, or more than four-fifths stayed, while out of 89,790 who came during the fiscal years 1920 to 1925, 73,019, or nearly four-fifths, remained.

Although total immigration has been reduced roughly to about a third by immigration restriction legislation enacted since the war, in actual numbers more professional aliens were admitted to the United States during the fiscal year 1924-25, when 10,481 entered, than in 1909-10, when only 10,334 came in. In 1923-24, the last year before the 2 per cent quota act went into effect, 24,778 professional people were admitted. The average ratio of professional immigrants to total immigration (including all men, women and children of all classes), for the years 1910-14 inclusive, was 1.2 percent while, in the fiscal year 1924-25, it was 3.6 percent or three times greater. Professional aliens, during 1911-14, constituted 1.9 percent of all male immigrants but, in 1924-25, amounted to 6.2 per cent of all male immigrants.

Safety Rules for the Installation and Maintenance of Electric Utilization Equipment

issued by the Bureau of Standards and obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C. Price 15c; 71 pages.

For some years the Bureau of Standards has been developing a National Electrical Safety Code in collaboration with the American Engineering Standards Committee and other interested bodies. This has now reached the fourth edition, each edition having been a complete revision. In the past the Code has been issued as a single complete volume, but in response to some demand for smaller books, each containing a single part of the Code, the present edition is published both in complete form and in sections.

The volume at hand contains that part of the Code which is of most general application, as it specifies from the safety standpoint the proper methods of construction and installation of electrical apparatus for the ultimate user. Some of the topics are: grounding, conductors, fuses, switches; switchboards, panel boards, motors, furnaces, batteries, transformers, signs, cranes, elevators, and telephones. One section is devoted to portable apparatus and as most appliances in the home are of this character these rules are of value and interest to everyone.

—*C. W. B.*

Aeronautic Engineering Meeting In August

Plans are being made for a two-day aeronautic engineering meeting to be held in Philadelphia by the Society of Automotive Engineers just before the national air races there. The dates selected probably will be August 30 and 31, and the place the Bellevue-Stratford Hotel. Considerable attention will be given in the addresses and discussion to the subjects of design, construction and operation of both heavier and lighter than air craft.

As the meeting will be held at a time when the Sesqui-Centennial celebration is in full swing, there will be a triple attraction for the 5,800 members of the engineering society in Philadelphia the last week in August and a large attendance is expected.

That aeronautics is occupying a prominent place in the minds of automotive engineers at this time is indicated by the fact that two days are to be devoted to the subject this year as against one day last year.

The Acid Test of Railroad Mergers

It is a remarkable feature of this question that the demand for the unification of the carriers has not come from the great body of the shipping public which is the principal user of transportation service. Many students of the problem are convinced that wholesale and arbitrary consolidation of railroads will not prove the unmixed blessing promised by the theorists on this subject, and that the building up of unwieldy systems, too large for adequate administration and supervision, is certain to bring serious impairment on the efficient service record American railroads have made in recent years.

Unquestionably there are advantages to be gained by permitting the consolidation of railroads, subject, of course, to the approval of the Interstate Commerce Commission, where unification can be made along normal lines and where it will bring about economies without impairing in any way the character of the service given the public. This last, however, should be the acid test and all other advantages urged in favor of mergers should be made subservient to the results to be obtained from the standpoint of the shipping and traveling public. Here, again, the public and particularly the owners of railroad securities may exercise a constructive influence through opposing any attempt at compulsory consolidation immediately or at any future time.

—*E. E. Loomis, President Lehigh Valley, in his 1925 report to stockholders.*

Conservation of Power in Industrial Plants

Discussed at a Meeting of

The Engineers Club of Philadelphia

February 16, 1926

Presiding Officer—Morning Session

Dr. Arthur M. Greene, Jr., Dean, Mechanical Engineering, Primary University

(Continued from page 133 of the May issue)

Plant Illumination

By WARD HARRISON
Director, Illuminating Engineering, National Lamp Works,
Nela Park, Cleveland, Ohio

I MAKE no claim to be a seer but, at the same time, I believe I know what is running through the minds of many of you and that is "What appropriate place has a paper on Better Lighting in a meeting on power conservation?" All I can say is, I did not solicit a place for this subject on your program. More than that, I have not come prepared to recommend a diminution of light in any industrial plant and the best defense of my position is that I do not believe there is any person in the United States, well informed on the subject of lighting, who would recommend a diminution. But I believe it is well to talk frankly, so there will be no misunderstanding between us. You remember the story of the young man, who had been dancing in silence with a beautiful lady, and whose thoughts took form in words, and who said, "I could go on dancing this way forever!" The beautiful young lady said, "Good gracious, Tom, don't you ever want to improve?"

From the standpoint of waste, I am heartily in accord with any movement to keep the lights turned off when there is no need for them, and I believe in preventing waste by keeping the lamps and reflectors clean. If every reflector in the United States were thoroughly washed and cleaned this afternoon, the level of artificial illumination tonight would be easily doubled. Really, using lamps and reflectors in a dirty condition is just as wasteful as it is to burn lamps when the plant is running and then let them burn also an equal number of hours after the plant has shut down. You would fire any employee who allowed that condition to exist.

A Practical Test

On the subject of lighting economies, I would place emphasis on practical tests which have been made in a number of industries and which show that supplying more light increases production and decreases unit cost. The results of one such test are shown graphically in Figure 1.

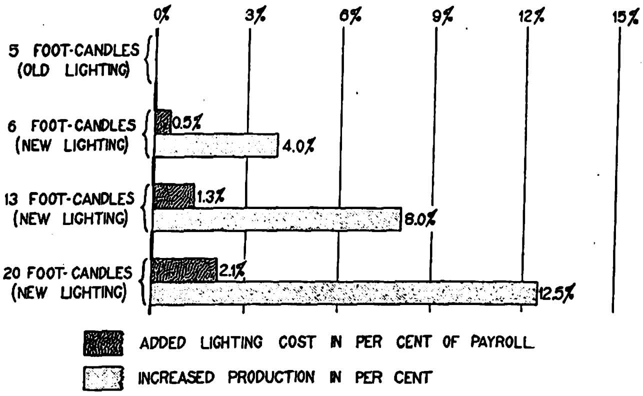

FIGURE 1

This investigation was completed not long ago in the Inspection Department of the Timken Roller Bearing Company at Columbus, Ohio. The number of bearings inspected per operator per hour was found, first, under the old lighting system providing an average of about 5 foot-candles on the work and, then, under well-designed systems providing 6, 13, and 20 foot-candles. Unusual care was taken to prevent any factors other than illumination from influencing the results. During the ten weeks of the test the humidity and the interior temperature were kept practically constant and the employees did not know their production was being investigated. The results of the test furnish proof that, for the class of work carried on in the Inspection Department investigated, the production is materially affected by the illumination supplied. Without exception, the production increased when the illumination was raised and decreased when it was lowered.

Under the old glaring lights, which gave only about 5 foot-candles on the work, the number of pieces inspected per operator per hour was 408. Under a well designed system, providing 6 foot-candles with a minimum of glare and objectionable specular reflection, the number of pieces inspected per operator per hour was 424, representing a 4% production increase over that obtained under the former faulty illumination of about the same foot-candles. Likewise, increasing the illumination from 6 to 13 foot-candles, with a well designed system, resulted in an output of 440 pieces per operator per hour, representing a 4% production increase and, when the illumination was raised to 20 foot-candles, the production increased to 458 pieces per operator per hour, which was an additional 4.5% increase. Thus, comparing the 20 foot-candle system with the one originally in use, a 12.5% increase in production is found. The figure shows these production increases and also the added cost of the better lighting.

The cost figures for the Timken installation are:

	Per hour
Cost of lighting (Current, lamp renewals, fixed charges, etc.) new 20 foot-candle installation	$ 0.32
Cost of lighting old 5 foot-candle installation	.04
Added cost of better lighting	.28
Hourly total wages of 44 inspectors	13.20
Hourly saving to Company through a 12½% production increase	1.47

Thus the saving to the Company is over five times the added cost of the better lighting. If these results were obtained in a laboratory and not in service, you would ask, "Do you find that to be true in practice?" In the present instance you will ask, "Do laboratory researches verify the practical tests?" I want to answer that and also the query "Do the answers check with common sense?"

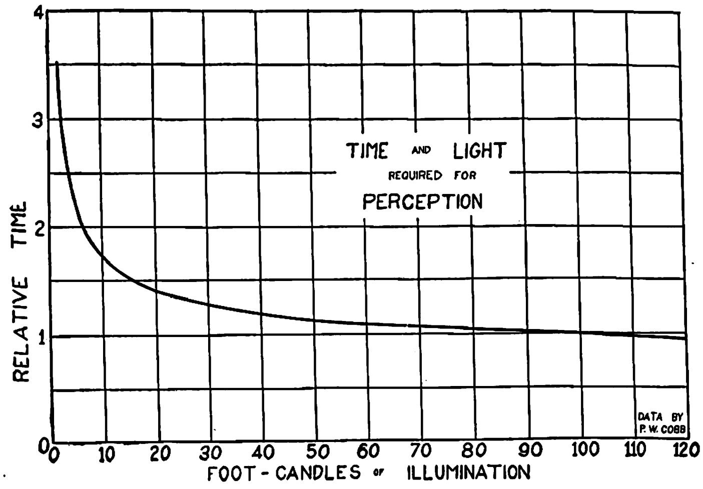

FIGURE 2

Confirmation from the Laboratories

I have here two or three charts which take up what has been done in the laboratory along these lines. Figure 2 is a chart showing the time it takes to see a small black spot in a white field, that is, the fraction of a second for which the spot must be exposed to view, in order to make a sure determination of whether it is there or not. The amount of light is expressed in foot-candles. The illumination in this room is about two foot-candles and that out-of-doors is about 1000. The best factory installations have about 10 times the level of illumination we have in here.

Likewise in tests that involve the fatigue of the eye, you find that decreasing the illumination causes a very rapid decrease in the clearness of vision.

One more chart, Figure 3, to bring us down to a basis of every day, records a laboratory test where subjects were given a long column of printed matter to read. It was found that increasing the illumination decreased markedly the number of seconds required to read a hundred words. From the chart you will see it took eighteen seconds to read a hundred words under one foot-candle and, at twelve foot-candles, only fourteen seconds.

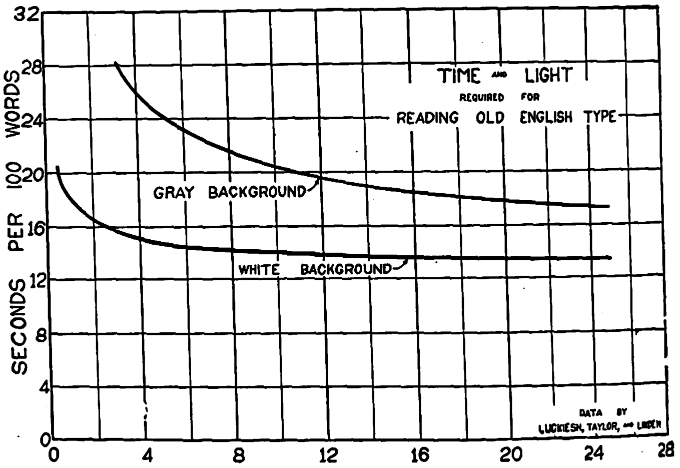

FIGURE 3

The Common Sense Side

Now, as to the common sense side of the lighting problem, there is not much I can tell you that you do not already know. Light is a very old subject—as old as the human race, and we all have our ideas on it. There is just one conception that perhaps some of you haven't dwelt on very much—that of our ancestors as daylight animals who, even in the days of chivalry, went to bed at half-past six or seven. Of course, there were a few who stayed out—especially those that preyed on others—but most of the people's work was done by day, out of doors, in the fields; even the cobbler ordinarily sat in front of his shop, or home, in the outdoor light. Now the light out-of-doors even on the shady side of the street on an ordinary day is substantially five hundred times what we have in a factory with all the lights burning and, if the question of inside work were under consideration by you for the first time—if it were a brand new thing like radio, there would be many lively debates going on as to whether a man could see to work at all with only one-five-hundredth of the illumination under which he was in the habit of working.

And it is a very fair question, yet the single fact that today fifty-three per cent of all the persons gainfully employed in this country have defective vision is proof that the change has not been made with complete satisfaction. At this point it should be emphasized also that it is certainly false economy to conserve power at the expense of the workers' eyesight or even at the loss of as little as 5% of his productive efficiency.

Just one word more, and that is "Why is it, if a better standard of interior lighting will do the things claimed for it, we have so much poor light?" Why is it that the average factory is illuminated to 2 or 3 foot-candles instead of 10 or 20. The only explanation lies in the old adage, "Familiarity breeds contempt." We have always had some kind of artificial light. Our grandfathers knew they could not work very well by the kind of artificial light they had, but put up with it, and many of us really have not comprehended the significance of the advances in this field since grandfather's day.

Presiding Officer—Afternoon Session

Dr. Robert A. Fernald, Director, Mechanical Engineering Department, University of Pennsylvania

High Pressure Prime Movers in Industrial Plants*

By FRANCIS HODGKINSON
Chief Engineer, Westinghouse Electric & Manufacturing Co.

THE use of what might be called "Extra High" Steam Pressures, or at least as high as 600 pounds, was advocated by some engineers occupied in the design of steam turbines more than ten years ago and, at that time, they showed that some 7% to 10% saving in fuel could be realized by this means. Among the reasons for not quickly adopting these higher pressure was that of increased boiler costs. Perhaps a more important one was the lack, by the individual who spent the money, of the required courage to try such a costly experiment and risk the serious loss that would follow should such a plant not prove reliable. I believe that, during the time since then, manufacturers of steam turbines have been prepared to design turbines for any of the pressures thus far proposed. This fact may not have been apparent to possible purchasers because the high development cost incidental to such designs (which, naturally, must be recovered by the manufacturer in some way) has, perhaps, in some instances made it appear, when bids have been invited, that manufacturers have not been intrigued by the prospect of building such machines. It is true, the thermal functions of steam at very high pressures are not known with accuracy and there are quite serious discrepancies between the various tables that have been published. However, none of these differ markedly in the energy to be obtained in the ideal engine from the steam expanding from a higher limit of pressure to a lower. At all events, the discrepancies are not such as seriously to affect the designer's calculations, on the one hand, or the ultimate economies to be secured in the power plant, on the other. Fortunately, such discrepancies as exist today will soon be largely removed by the activities of the American Society of Mechanical Engineers, under the direction of Mr. George Orrok, who has already partly completed valuable research, the expense of which is being borne in part by the turbine manufacturers of the country. The General Electric Company is to be credited with some research of this character and they have compiled some comprehensive curves from the preliminary A.S.M.E. data which, through the courtesy of its representatives, were made available to Engineers at the December meeting of the Society.

Efficiency Well Lost

It is to be expected that turbines to operate with extra high pressures will be less efficient (using the term, "efficiency," in the strict sense) than those designed to operate with moderate pressures because of the relatively small volume and high density steam at the high pressure portion, rendering highly efficient turbine elements more difficult of attainment, and the greater precipitation of moisture throughout the cycle, adding friction to the low pressure elements. This precipitation may be reduced or nearly eliminated if reheating with its complexities is resorted to or if a successful means is employed of draining the moisture from the turbine as latent heat is given up during expansion. In a measure, this last may be accomplished where stages of the turbine are bled for some industrial process or where the regenerative principle is made use of in a plant heating its own feed water by stage bleeding and the details of turbine construction are such as to discharge the maximum of the precipitated moisture to the heaters.

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*Paper read before the Engineers Club, Philadelphia, February 16, 1926.

In a paper I had the honor of presenting before the World Power Conference in London in 1924, I described such turbines and showed that, with an increase of pressure from 200 to 1200 pounds, we estimated the engine efficiency (Rankine Cycle Efficiency Ratio) of large turbines would fall off approximately 2.2%, with a saving, however, of approximately 14% in heat consumption in the steam supplied. This result we obtained without taking cognizance of the advantages to be derived from reheating or stage feed water heating, which reduce the heat consumption per unit of energy at a greater rate as higher pressures are reached and are, therefore, more desirable with higher pressures.

Other authors confirmed this. Sir Charles Parsons, taking into consideration lower boiler efficiency for higher pressures, which perhaps is not warranted, predicted a saving in fuel consumption of 10% for 1,000 pounds pressure and 16% for 2,000 pounds pressure, as compared with 250 pounds pressure.

Mr. B. Nördstron, of Sweden, makes similar promises, 750 deg. F. total steam temperature being assumed in all cases.

The general thermal advantages of high pressures can be seen in Table I, showing the gains over 200 pounds absolute pressure, 200 deg. superheat, first, with constant total heat in the steam supplied to the throttle, second, with constant superheat and, third, with constant total temperature. The performances are based on that of an ideal engine in all cases.

TABLE I

EFFECT OF HIGH STEAM PRESSURES (THEORETICAL)

CALCULATED FROM CALLENDAR'S TABLES

29″ Vacuum—79 Deg. Feed Water

At Throttle						% Gain Compared with 200 Lbs. Abs. Press., 200° F. Superheat	
Press., Lbs. Abs.	Total Heat, B.T.U.	Super-Heat, ° Fahr.	Total Temp., ° Fahr.	B.T.U. Drop Adiabatic Expansion	Quality of Exhaust, %	Per Unit of Steam Supplied	Per Unit of Heat Supplied
			Total Heat Constant				
200	1317.5	200	582	418.5	.815	0	0
350	Do.	169	601	450.5	.784	7.7	7.7
600	Do.	143	630	481.5	.755	15.1	15.1
1200	Do.	117	684	519.5	.719	24.1	24.1
			Superheat Constant				
200	1317.5	200	582	418.5	.815	0	0
350	1334	Do.	632	458	.793	9.4	8.1
600	1350	Do.	687	497	.771	18.7	15.8
1200	1370	Do.	767	547	.743	30.7	25.6
			Total Temperature Constant				
200	1405	368	750	464.5	.855	11.1	3.9
350	1397	318	Do.	493	.821	17.8	10.9
600	1385	263	Do.	516	.785	23.3	19.4
1200	1360	183	Do.	542	.738	29.4	25.4

It is believed that engineers occupied in the designing of turbines foresee no particular difficulties in design for even the highest pressures thus far contemplated. It is fair to say, however, that not much is known concerning the erosive effect of this high density steam and engineers will be wise, for the present at least, in designing these elements multi-stage and employing relatively low steam velocities.

Superheat Another Matter

The designing engineer would be more concerned and fearsome should corresponding increases of superheat be proposed and it is likely that, for some time to come, he will not subscribe to temperatures much higher than the maximum practice of today—750 deg. F. total. It is reported, however, that turbines in Europe are being constructed for 1,800 pounds, 925 deg. F. total temperature. Considerable research has been carried out, and much is yet to be done, in the matter of the physical characteristics of various materials, under stress and high temperatures over long periods. This research includes fatigue limits and determinations of elastic modulus. Short time tests of different materials at elevated temperatures have been available for some time but further experimenting is being done to determine the effect of long continued stress and temperature. It may be this research will render available materials sustaining in their strength at higher temperatures than do those we have, making higher superheats possible. Lack of strength, however, is not the only difficulty; there is distortion of the elements of the turbine, due as much to differences of temperature in the same structure as the temperatures themselves and interfering with the labyrinths and blade clearances.

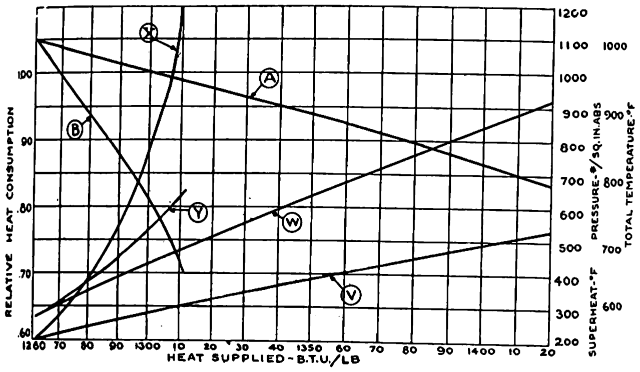

FIGURE 1

INCREASING PRESSURE VS. INCREASING SUPERHEAT

Curves showing relative gain in heat consumption plotted against heat supplied, compared wth 200 lbs. abs. pressure—200° Superheat in an ideal engine—29 in. vacuum in all cases. Calculated from Marks and Davis' Steam Tables.

A—Relative heat consumption due to increasing the superheat and maintaining the pressure (200 lbs. abs.) constant—the pressure increasing as shown by Curve V—the total temperature increasing as shown by curve W.

B—Relative heat consumption due to increasing the pressure and maintaining the superheat (200° F.) constant—the pressure increasing as shown by curve X—the total temperature increasing as shown by curve Y.

Fortunately, however, it is by increasing the pressure that far greater gains in heat consumption per unit of energy are to be secured, at least in cases of large turbines. This is exhibited by the curves of Fig. 1 as applied to an ideal engine. The curves show, for instance, that if 50 more B.T.U. per pound of steam are added by the boiler, in addition to that incidental to 200 pounds pressure, 200 deg. superheat, there will be a 6% theoretical gain in heat consumption if this heat is added as superheat; the superheat then becoming 300 deg., the steam having a total temperature of 685 deg. If the same 50 more B.T.U. per pound of steam are added by the boiler in giving increased pressure, maintaining the superheat the same, there will be a 33% saving in heat consumption; the pressure approximating 1,100 pounds, the superheat, as stated above, 200 deg., and the total temperature at 765 deg.

These curves, being based on the performance of the ideal engine, must not be taken at their face value. In practice, the engine efficiency or Rankine cycle efficiency ratio is slightly higher, the higher the superheat, on account of reducing the moisture in the turbine. There are other reasons, having slight effect, because of the lesser density of steam, due to the higher temperature, reducing the fluid friction effects. There is perhaps also some small effect from the so-called "supercooling," the superheated steam trying to expand as a perfect gas and at such speed that moisture particles do not precipitate. The curves also assume equal efficiency of 100% for all elements of the turbine. There may also be inaccuracies in the higher pressures because of uncertainties in the steam tables within these ranges.

Small Capacity Turbines

In the designs of small capacity turbines, where the high pressure volumes are small, it is difficult to design the high pressure elements of small enough an area that the turbine can avail itself of the pressure and be efficient. There are instances where, in turbine elements added to the high pressure end for the greater heat drop, their leakage ratios become so high there are little or no gains on account of the higher pressures. This is especially true if a high rotative speed commensurate with the steam volumes is not available. It was frequently found by turbine designers of 30 years ago, in cases of direct connected turbines of small capacity and low rotative speed, that better results were secured by wire drawing the steam through the governor valve to a lower pressure and greater volume. In such cases, it is obvious there would be no gain by increasing pressure but a substantial gain would be secured by increasing the superheat. Today, however, such cases of difficulty in securing efficient design of the high pressure element need not be general, for any desired rotative speed may be employed for the high pressure element by means of tooth gearing. In spite of prejudices in some quarters to the contrary, properly constructed gears may be quiet running and are as reliable as any other piece of machinery in the power plant and have efficiencies of not less than 96% or 97%. Their ruggedness and reliability are shown by the fact that European manufacturers are generally coming to employ geared units for all their 50 cycle work up to about 1500 K.W.

Generally speaking, from the turbine designer's standpoint, the application of extra high steam pressures to large turbines, such as are employed by public utility companies, is an easier problem than their application to the smaller capacity units used by industrial companies. Usually, in cases of large power units, separate high pressure turbine elements will be employed, expanding the steam, from the extra high pressure desired, to a convenient, relatively high, exhaust pressure, perhaps one selected as the best pressure at which to apply reheating, after which it is employed in other turbine units wherein it is expanded to the condenser pressure. In such instances, a capacity of high pressure element may sometimes be selected that will more or less best suit the turbine design, perhaps a single high pressure unit serving several low pressure units.

The Westinghouse Co., a few years ago, completed designs for turbines to operate between pressure limits of 1200 and 300 pounds, in which the high pressure turbines would exhaust into the main steam pipe to a group of normal turbines in which a flow of 125,000 pounds per hour had been selected. This quantity is indeed small, twice the amount being a more satisfactory volume from the turbine designer's standpoint and lending itself more readily to a rugged and efficient design of a 60 cycle, 3600 r.p.m. turbine.

However, to properly handle the high density and small volume of steam throughout the high pressure element, high rotative speeds, not necessarily high blade speeds, may generally be employed, direct connected for large and geared for the smaller capacities, thus reducing the physical dimensions of the turbine proper and in turn reducing the probabilities of distortions of the turbine parts due to temperature itself and the differentials of temperature.

A problem in the design of such turbines, on account of the large sized steam lines, massive steam valve gear, long and strong exhaust pipes, is to design the turbine so that it will not be affected or its alignment disturbed by the expansion of these parts. This, however, is readily mastered by those with experience and skilled in the practice of such methods.

Industrial Applications

Thus far I have rather indicated that high pressures do not lend themselves to the designs of turbines for the smaller units used in industrial plants except by means of gears, which is at least partially true and, perhaps, renders high pressures inapplicable to the industries unless steam of some pressure is required for some industrial process. In fact, it may be fairly said that, unless the industrial plant has need of steam heating in some form, it would be impossible for it to justify the installation of a power plant, in view of the service which may be rendered by the public utility company in most districts. This will become truer when more so-called "super-power" schemes are extended and cheap energy is available in more places.

There are cases in the industries where steam is not required for any process but where a number of buildings must be heated during cold weather. In such instances, the installation of non-condensing turbines should be justified and mutually satisfactory arrangements be possible with the public utility company whereby the industry would take less energy from the utility company in the winter months, when the utility company's loads are heaviest, and more during the summer months, when loads are usually lighter. Similarly, in instances where exhaust steam at some pressure is used for process work but the energy requirements are in excess of what could be obtained from this steam at any practicable high pressure, the highest practicable pressure may be selected and expanded in power units to the pressure desired by the heating process, the flow through the power unit being controlled by the requirements of the process and the difference between the energy thus given and that required being supplied by the utility company. If, on the other, hand, energy from the utility company is not available or, for some reason, satisfactory arrangements cannot be made, bleeder type turbines, or combinations of high and low pressure elements, may be furnished, in which any proportion of steam may be delivered at any of the lower pressures for a variety of processes, and the extra energy may be secured by turbines expanding additional steam from the boiler pressure to a condenser pressure. This, after all, is cheap energy, since all the fixed losses in the turbine and generator have been taken care of and, by virtue of the large volumes passing the high pressure turbine elements, the turbine efficiency will be increased. In fact, with the charges in the industrial power house properly apportioned, the public utility company will find it hard to compete. Unfortunately, however, there are so many varieties of pressures and ratios of process heating requirements to energy requirements that the problem is difficult to meet with standard pieces of apparatus, thus requiring either high fixed charges because of special development, on the one hand, or lowered efficiency because of attempts to use standard apparatus, on the other.

In power plants, where the industry requires steam for some process, high pressure units may be installed which can expand down to process pressure giving large amounts of energy at almost no cost beyond fixed charges, and the selection of pressure and temperature to be employed is determined by the quality of steam desired for the industrial process, the amount of energy required, and the capital cost.

An interesting paper on "The Value of Higher Steam Pressures in the Industrial Plant" was presented at the December, 1925, meeting of The American Society of Mechanical Engineers by William F. Ryan, who speaks from the authority of a company that, possibly, has done more than any other in bringing about thermal savings in an industry involving a number of elaborate evaporating and heating processes.

The employment of extra high pressures means care in the design of the plant that it may be simple. Every unnecessary high steam pressure pipe line must be eliminated or the cost of small valves may become enormous. Presumably, in all cases, distilled water only will be used as make-up for the boilers so that complexities of evaporators are involved and, in consequence of these things, it has been said there would be risk in applying high steam pressures to an industrial plant because of less operating skill than is available to the large public utility company. I make no expression of opinion on this point, though I have evidence enough of all kinds that I could hold as good a brief for the skill of the average industrial plant operator as for the operator of our large utility plants, or vice versa.

An Interesting Example

By way of example of an industrial plant, an assumed case is taken, and shown in Table II, based on an industrial requirement of 100,000 lbs. per hour of steam at 100 pounds gauge pressure. The table shows the energy to be obtained, with a variety of initial pressures, at 750 deg., total temperature, expanding to the above back pressure. Of course, the higher the initial pressure, the greater the amount of available energy for power purposes and the less the superheat discharged for the industrial process, so that, for the lower initial pressures, perhaps a lesser superheat might result in less total charges. The table gives the cost, including fixed charges, properly apportioned respectively to the industrial process and to energy production; it is based on test conditions. The industrial operation and energy production are taken as being continuous; in other words, 100% load factor operation while operating is assumed. The following cost assumptions are made for plant operating at 375 pounds pressure:

Cost of complete boiler plant..........	$ 63 per K.W.
Cost of complete engine room, building & equipment, excluding condensing equipment	68 per K.W.
Cost of complete condensing equipment, including condensing water system	19 per K.W.
Total cost of entire power plant...	$150 per K.W.

The above figures are for a plant operating with straight condensing turbines. For determining the cost of boiler equipment for a plant furnishing process steam, it is assumed one boiler H.P. at 200% rating will supply steam for 4.7 K.W. from a condensing turbine. Then the cost of boiler plant per boiler H.P. installed will be $296.

Annual cost of maintenance, personnel, and supplies, not including executive administration for bolier room..................	$20,000
Annual cost of maintenance, personnel, and supplies, not including executive administration for engine room................	15,000
Coal—12,500 B.t.u. per pound.........per ton	$5

Annual fixed charges—15% of capital expenditure.

The following efficiencies are assumed:

Boiler, furnace, and grate....................	76%
Turbine (engine efficiency)	70%
Generator	95%

For increased pressures, it is assumed the only change in power plant cost per K.W. rating is in the boiler plant and a small additional cost in the turbine. The boiler plant cost is increased 15% for 600 pounds and 80% for 1200 pounds over the figure given for the 375 pound plant. Labor remains the same.

These boiler house ratios of cost have been taken from Mr. Ryan's paper, above mentioned.

Capital expenditures will vary with every case, and the assumptions made are necessarily to be regarded as only approximate.

The costs, prorated between the industrial process and energy production, are based on the respective amounts of heat energy going to each. The cost of the boiler house is apportioned in the same ratio. The engine room and its operation has all its costs and fixed charges placed against energy production for, were it not for generating energy, no engine room would be required. Should the operation continue during the day time only, i. e., for an eight-hour day, the costs would increase to those shown in Table II-a. Because of banking fires, 70% boiler efficiency is assumed. The labor cost is cut in half.

The case is carried somewhat further with the supposition that the energy shown by the previous Table II is not sufficient for the energy requirements and 4000 more kilowatts are required. These additional kilowatts, as has been previously indicated, may be purchased from a public utility company or, instead of the back pressure turbine, a bleeder type turbine may be installed in which a sufficient quantity of steam is admitted at the throttle for 100,000 pounds to be bled at 100 pounds to this process heating, the same as before, and the remainder to expand to a condenser in which 28½ inches vacuum is maintained.

Table III shows, under the above assumptions, the cost of this additional energy which is low because much of the fixed losses in the machinery have already been charged and because of the low fixed charges due to the small additional investment for a slightly more complex and larger turbine and a condenser to condense only a fraction of the total steam.

In the table it is assumed that this addition to the plant costs, for the boiler plant, .8 of the original boiler plant horse-power cost and, for the engine room, $51.00 per kilowatt, excluding condensing equipment, which will be additional apparatus. No increase in labor and maintenance cost is taken for the engine room. The boiler house labor costs have been increased 40% for this increase in boiler capacity.

Elements of Plant Design

Probably the only method of discovering the most economical pressure and superheat to be employed and the most economical combination of machinery in an industrial plant is to estimate as correctly as possible the probable load conditions and heating operations and then go through the somewhat laborious process of tabulating annual operating costs, including fixed charges, with all conceivable combinations with and without purchased energy.

The pressure selected depends upon the reasons given, viz., fixed charges, and the amount of energy desired from the process steam relative to that de-

TABLE II

	PRESSURE FOR WHICH PLANT IS DESIGNED		
	375 Lbs.	600 Lbs.	1200 Lbs.
Steam required for industrial process, lbs. per hour	100,000	100,000	100,000
Superheat at turbine exhaust with 750 deg. initial temperature	191°	126°	3°
Boiler H.P. installed (operating at 200% rating)	1,800	1,790	1,740
K.W. capacity of turbine with 100 lbs. exh. pres.	2,620	3,360	4,270
Coal used—tons per year (6,500 hrs.)	41,100	40,900	39,800
Total steam generated per year (6,500 hrs.)—in lbs.	650,000,000	650,000,000	650,000,000
Total K.W. hours generated per year (6,500 hrs)	17,000,000	21,850,000	27,750,000
Per cent of heat generated chargeable to industrial process	92.2	89.9	86.8
Per cent of heat generated chargeable to energy production	7.8	10.1	13.2
Cost of complete boiler plant	$533,000	$610,000	$927,000
Cost of complete engine room—building and equipment	$178,000	$228,500	$290,000
Total capital cost of plant	$711,000	$838,500	$1,217,000

	375 Lbs.		600 Lbs.		1200 Lbs.	
	Industrial Process	Energy Production	Industrial Process	Energy Production	Industrial Process	Energy Production
Fixed Charges on Investment—						
Boiler plant	$ 73,760	$ 6,240	$ 82,250	$ 9,250	$120,650	$ 18,350
Engine room	......	26,700	......	......	......	43,500
Labor and Maintenance—						
Boiler plant	18,440	1,560	17,980	2,020	17,360	2,640
Engine room	......	15,000	......	15,000	......	15,000
Fuel cost	189,500	16,000	184,000	20,680	172,800	26,260
Total annual cost of operation	$281,700	$65,500	$284,230	$81,200	$310,810	$105,750
Cost of steam per 1,000 lbs.	.433c	......	.437c	......	.478c	......
Cost of electric energy per K.W. hour	......	39c	......	37c	......	38c

TABLE II-a

	PRESSURE FOR WHICH PLANT IS DESIGNED		
	375 Lbs.	600 Lbs.	1200 Lbs.
Total steam generated per year (2,170 hrs.)—in lbs.	217,000,000	217,000,000	217,000,000
Total K.W. hours generated per year (2,170 hrs.)	5,680,000	7,290,000	9,260,000
Coal used—tons per year (2,170 hrs.)	14,900	14,840	14,440

	375 Lbs.		600 Lbs.		1200 Lbs.	
	Industrial Process	Energy Production	Industrial Process	Energy Production	Industrial Process	Energy Production
Fixed Charges on Investment—						
Boiler plant	$ 73,760	$ 6,240	$ 82,250	$ 9,250	$120,650	$ 18,350
Engine room	......	26,700	......	34,250	......	43,500
Labor and Maintenance—						
Boiler plant	9,220	780	8,990	1,010	8,680	1,320
Engine room	......	7,500	......	7,500	......	7,500
Fuel cost	68,700	5,800	66,700	7,500	62,660	9,540
Total annual cost of operation	$151,680	$47,020	$157,940	$59,510	$191,990	$80,210
Cost of steam per 1,000 lbs.	.70c	......	.73c	......	.88c	......
Cost of electric energy per K.W. hour	......	83c	......	82c	......	87c

TABLE III

	PRESSURE FOR WHICH PLANT IS DESIGNED		
	375 Lbs.	600 Lbs.	1200 Lbs.
Additional condensing capacity to back pressure plant—K.W.	4,000	4,000	4,000
Additional boiler H.P. required	860	820	770
Additonal steam generated—lbs. per hr.	43,700	41,700	39,900
Additional coal used—tons per year (6,500 hrs.)	19,780	18,780	17,540
Additional K.W. Hr. generated per year (6,500 hours)	26,000,000	26,000,000	26,000,000
Cost of addition to boiler plant	$204,000	$223,000	$329,000
Cost of addition to engine room—building and equpment, excluding condensing equipment	204,000	204,000	204,000
Cost of complete condensing equipment	76,000	76,000	76,000
Total capital cost of addition to plant	$484,000	$503,000	$609,000
Fixed charges on investment per year	$72,600	$75,500	$91,400
Additional labor and maintenance cost per year	6,000	6,000	6,000
Fuel cost per year	98,900	93,900	87,700
Total cost per year for additional power	$177,500	$175,400	$185,100
Cost per K.W. Hr. for the additional power	68c	67c	71c

manded by the heating steam. The best initial temperature is generally that which will give approximately dry saturated steam or a few degrees of superheat to the process, for the heat in the steam in the form of superheat can be but little more usefully used in the heater than in a steam engine or turbine. Besides, because the superheated steam is a gas and of low specific heat above the point of saturation and there is, hence, a low rate of heat transmission in the heater, many times more area of surface is required. On the other hand, the heat in the steam, in the form of dry saturated steam above the heat in the liquid, can all be absorbed by the process, while the best engine can use but some 22% of it.

In the industries there are cases where either water or some liquor merely has to be heated from some normal atmospheric temperature. In such instances, considerable savings are to be obtained by heating the liquor by bleeding the turbine in stages in the same manner as is economical in similarly heating feed water. An instance of this kind occurred in an industry a short time ago where it was required to heat 870,000 pounds of water per hour from 115 deg. to 210 deg. F. In addition to this, there were required 2500 K.W. of additional energy. The purchaser contemplated bleeding steam direct from the boilers at 150 lbs. gauge pressure for this heating and, in addition, the installation of a 3500 K.W. condensing turbine. On the recommendation of the manufacturer, the installation adopted was a turbine to the throttle of which 102,000 pounds of steam would be admitted and which would be bled in three stages for progressively heating water to 148 deg. F., 179 deg. F. and 210 deg. F. When operating under these conditions, the turbine would produce 4610 K.W., obviating the necessity of the 3500 K.W. condensing turbine and reducing the load on the condensing units already installed. The change in arrangement resulted in a reduction of capital expenditure of about $42,000, this being the difference in price between the straight condensing unit, with the additional boilers that would have been required, and the cost of the complete bleeder unit. Furthermore, the annual fuel operating expense was reduced from $452,000 to $310,000, based on the cost of steam, including fixed charges, of $.44 per 1000 pounds, which was the cost of steam at the time the new plant was projected. The saving obtained amounted to $148,300 per year.

As a general proposition, a turbine required to heat a liquor having a specific heat of 1, from 80 deg. F. to 210 deg. F. in a single stage heater will develop 38.8 K.W. per 1000 pounds of steam, assuming throttle steam at 150 pounds gauge, 100 deg. F. superheat and a turbine efficiency of 70%. If this same heating were done in three progressive stages to 125 deg. F., 172 deg. F. and 210 deg. F., respectively, the same quantity of steam, 1000 pounds, would develop 51.3 K.W., an increase of 32% for no cost beyond the increase in the initial cost and fixed charges incidental to a slightly more complex turbine and the substitution of three smaller heaters.

Discussion

W. B. FLANDERS (Westinghouse Electric & Manufacturing Co.): There were a few points that I would like to touch on. Mr. Hodgkinson, I think, still left rather an indication that in the smaller industrial plants the turbine problem did not offer very much encouragement to higher pressures. There is the problem of the increased density and the very small volume of steam as you get to the higher pressures. There are also increased frictional losses and leakage losses. On the other hand, as I see it, the ideal industrial application will use the steam after going through the turbine, as pointed out; and there seems to be no reason why, practically, the turbine process or the steam going through the turbine, cannot be kept superheated, so that that loss can be largely overcome, offering, perhaps, a little further field for improvement than was indicated. The steam will exhaust then, at the saturated or slightly superheated point for transmission to the various points where it would be used in the industrial processes.

I think it has been pretty well demonstrated that there is less radiation through steam piping with moderately superheated steam at the same pressure than there is with wet steam, which offers some indication that moderately superheated steam is not undesirable.

Another point I think is strongly indicated; and that is that few users will employ above 750 degrees total temperature. As pointed out, there has been a great deal of investigation going on as to the behavior and use of materials at the higher temperatures; and I think there is a great deal of ignorance still. We have had some practical difficulties in piping and fittings with temperatures much over 700 degrees. I know of one case particularly where the temperature runs as high as 780 degrees in the steam lines; and they are having continual trouble by loosening up of the joints. The bolts are apparently stretching. They are tightened up, and the joints stay tight for a while and then begin to blow; they go over them and find they can take up another turn or two on the nuts. The physical tests available show that that material has a high elastic limit at 750 degrees; but still there is a gradual flowing of that metal under the temperature, until the bolt actually stretches and releases the joint.

Another thing I think can be emphasized to advantage, and that is the value of high pressure rather than high temperature. That is rather startling to most of us. For a given additional B.T.U. in the boilers there is much more to be gained by putting it into pressure than into temperature.

We have an idea that the more you make the steam engine approach the gas engine the more may be attained. That theory must be scrutinized very carefully—the pressure gain being offset, however, by that problem to the turbine designer of the small volume of the steam and the unavoidable leakage losses and frictional losses, which I think perhaps the author did not quite touch on.

Furthermore, losses in this high density, high pressure steam become very real; and they, as much as the leakage losses, determine the necessity of going to high speeds and small physical dimensions at the same peripheral speed. A disk revolving in a high pressure will have four times the frictional loss at 1800 r.p.m. of one of half the diameter at 3600 r.p.m.

In speaking of the special unit, where the problem was to heat feed water and incidentally get energy out of the steam while doing it, the first thought was to modify the regular standard machine so as to get 3600 kilowatts; but we modified it a little further and introduced a further stage of bleeding and got 3900 kilowatts, heating the same amount of water; and found that by making the special machine for that one purpose we could more than save, in two years, the cost of the development of that machine. And that was what was finally adopted. Although the standard machine modified would have cost considerably less, the special machine was more than justified because of the saving in losses.

LINN HELANDER (the U. G. I. Contracting Company): The application of the extraction turbine discussed by Mr. Hodgkinson is an encouraging example of what may be accomplished by the more extensive use in industrial plants of those principles of regenerative feed-water heating that have proven so highly advantageous to central stations. This turbine, Mr. Hodgkinson points out, will produce 4610 K.W. of by-product power and a consequent annual savings of $148,300 by reason of its ability to supply bled steam for the multiple stage heating of 870,000 pounds of water an hour from 115 degrees to 210 degrees. It is particularly significant that the application, in spite of the development charges against the turbine, was made with a lesser total investment than would have been required for a straight condensing plant; the savings in boiler plant investment having more than offset the development charges.

If the conditions under which the extraction turbine was installed may be considered fairly representative, then an industrial plant requiring a similar heating of 300,000 pounds of water an hour, which is not an uncommon requirement, could develop approximately 1600 K.W. as a by-product of its water heating processes alone. This would indicate that the advantages of using bled steam for the multiple stage heating of process water are in no small measure present where the demands for heated water are moderate, though obviously they are more pronounced where large quantities of water are to be heated. An additional advantage exists for plants that hesitate to generate high pressure steam because of the quality of the available boiler feed water. The condensate from the various heaters may be recovered as pure distilled water and used as the feed water for high pressure boilers. The steam from these high pressure boilers then may be used in a separate high pressure non-condensing turbine or directly in the heater turbine, provided this turbine is designed for high pressure operation.

In the case of the system described by Mr. Hodgkinson, the pure water that may be recovered as condensate from the heaters amounts to 102,000 pounds an hour. If this amount of condensate is fed to boilers and converted into steam at 600 lbs. per sq. in. pressure, and the steam so generated is expanded in a turbine to a process steam pressure of 150 lbs. per sq. in. gauge, the by-product power obtainable will be 2500 K.W. If the same steam conditions are assumed for the case of a smaller plant, one requiring, for example, 300,000 pounds of water heated 200 degrees, the by-product power obtainable from a combination of a heater turbine and a high pressure non-condensing turbine will be approximately 3500 K.W., 1600 K.W. of which would come from a high pressure plant using only bled-steam condensate for its boiler feed. Assuming a difference between the cost of by-product power and that of power from a condensing plant as 5 mills, the consequent savings would be $140,000 a year of 8000 hours. If economizers or other heat recovery equipment for heating the water are in use, the savings from the feed-heater turbine will be less than is represented above. But, as in the case of the central station, such economizers will only partially, and usually only in a small measure, off-set the gain from the use of regenerative heating.

That the use-factor has an important influence on the cost of by-product power from a high pressure plant is clearly brought out by Tables II and II-a of Mr. Hodgkinson's paper. Fuel charges are the same, labor and maintenance charges show only a small difference, but fixed charges have been multiplied threefold by the reduction of the annual output from 21,850,000 K.W. hour to 7,290,000 K.W. hour. For a particular plant, investment charges will be further determined by the rating at which the turbines and boilers may be operated and the advisability of making supplementary investments contributing to the economy of the high pressure power plant.

It may, for example, be advisable to make additions to the process steam distributing pipes in order to reduce the pressure at the exhaust of the turbines. Also, although it is most certain that the economy in the use of high pressure equipment will not warrant the extensive replacement of new boilers, it may prove advantageous to anticipate the obsolescence of low pressure boilers some years previous to their obvious necessary abandonment in order to install capacity in high pressure non-condensing turbines and high-pressure boilers sufficient to carry the immediate power load requirements of the plant. In this way, a more costly obsolescence of temporary lower pressure condensing equipment may be sometimes avoided. The cost of discarding the operative boilers, however, should be borne by the power plant.

The following estimate indicates that by-product power from a high pressure non-condensing power plant, supplying 100,000 pounds of process steam an hour at 150 lbs. per sq. in. gauge, may be obtained for approximately ½ cent per K.W. hour, including all apportioned charges.

Estimated cost of by-product power:

Steam pressure at turbine throttle . . 550 lbs. per sq. in.
Steam temperature at throttle . . . . . 700 Deg. Fahr.
Number of hours turbine operates per year 8000

	Cents per K.W. Hr.
Fixed charges	.2720
Fuel charges including blow down. (Cost of fuel 26.3c per million B.T.U. delivered by boilers)	.1075
Labor and maintenance	.0975
Superintendence and Operating overhead	.0300
Total	.5070

Auxiliary power and miscellaneous power requirements chargeable against the power plant have been estimated as 5½% of the power generated. The investment basis for fixed charges was determined by adding the cost of the generating room to the excess cost of the high pressure boiler plant over that of a boiler plant designed to deliver steam directly to processes. The fixed charges on the remaining investment are then carried by those processes that use process steam. With this method of apportioning the fixed charges, the charges against processes for the steam consumed by them are practically the same whether the process steam is obtained directly from 150 lb. pressure boilers or from the exhaust of the high pressure turbines.

The operator may be more interested in the marginal cost of power than in a cost carrying its apportionment of distributed plant operating charges. The marginal cost of power, based on the above conditions, may be appreciably less than ½ cent per K.W. hour.

MR. N. E. FUNK (Philadelphia Electric Company): I was very much interested in Mr. Hodgkinson's paper, and I think there was one thing he showed very clearly; but maybe because it was on two different slides it was not appreciated as much as it might have been by the audience; that is that the change in the load factor on a plant makes a tremendous change in the cost. The investment is a high factor in total cost of energy, whether steam or electrical, especially at low load factors. Another thing I desire to speak about is this: We have not had so very much experience in maintenance cost, so far as high pressures are concerned. These pressures have not been in use enough years.

There is one thing that has happened in several instances now, that is entirely different in performance from a low pressure plant, and that is in the failure of boiler tubes. In a low pressure plant if one boiler tube splits or punctures, the failure usually consists of the failure of that one tube. In several cases, in higher pressure plants, when a tube has been damaged it has damaged an area in front of it quite extensively, to such an extent that the tubes in front of this broken tube had to be removed. This is no reflection on the boiler designer or on the manufacturer; it is merely due to the fact that considerably greater energy is released in a given time and the tubes warp and twist out of shape, and must be renewed. This must be taken into consideration in figuring the maintenance cost of high pressure boilers.

At present there are not enough figures available to obtain a good average cross-section of what the ratio of lower and higher pressure boiler plant maintenance will be; so that in making estimates of possible cost we should bear in mind that our present knowledge of maintenance cost may lead to very optimistic estimates if we apply it without a reasonable factor of increase for the higher pressure plants. I do not think that this is any argument against the use of higher pressures, but it will increase the operating cost of the higher pressure plant over and above the lower pressure plant cost; and in those cases where the cost is very close it might easily justify a decision in favor of the lower pressure plant installation rather than of the high pressure plant.

FRANCIS HODGKINSON: Mr. Flanders' discussion is of interest.

While the radiation loss from pipes conveying superheated steam is less than with saturated steam, superheated steam is far less desirable in industrial process work than saturated steam because of the many times greater quantity of heating surface required before saturation is reached in the process of condensation in surface heaters of any kind. The paper endeavored to show the savings to be secured by means of increased pressures as compared with increased temperatures. It should be noted that Curve B of Fig. 1 shows performance with varying pressure and constant superheat, the total temperature, therefore, increasing with the pressure. Had this curve been drawn with constant total temperature, it would have gone in the opposite direction, showing the higher the pressure the less the heat consumption and at the same time less heat supplied by the boiler.

In turbine design, questions of leakage losses because of small volumes, and windage losses because of high density steam, are extremely important, as Mr. Flanders points out. These and other losses are all dependent upon rotative speeds and volumes of steam, as shown in the paper. There are limiting conditions where no heat savings could be accomplished by increasing pressure. These, however, may generally be removed by the application of reduction gears.

I gather from Mr. Helander's discussion that his estimate for power costs of plants, such as I have described, is higher than I have shown in the paper. I had rather expected the figures I have given would be challenged by some industrial plant engineer on the basis that he was able to show costs lower than I have estimated.

Important factors which determine the cost of energy are fixed charges and the load factor, each of which will depend upon the particular circumstances and location, and the paper is clear in stating that for these reasons the costs can be regarded only as approximate, but they do serve as a method or basis of such estimating or accounting. Annual operating costs must be tabulated in each instance.

The paper has generally shown higher energy costs at the highest pressures. This is due of course to the greater fixed charges on account of the boiler house costs, which have always struck me as being inordinate. If we should attempt to build a boiler for about 3200 pounds pressure, where latent heat is zero and water is converted into steam without ebullition, we would doubtlessly do as has already been done experimentally in one case in Europe—construct a boiler with small tubes and without drums, in other words, a flash boiler. Of course, such a type of boiler could not be used for low pressure, because the violent ebullition would drive water into the steam pipe. It does not follow, however, that the flash boiler principle could not be carried out for such pressures, say of 1200 pounds, eliminating the necessity of costly drums. Inasmuch as distilled water would be used for make-up in all cases of extra high pressure, the heating surface may comprise relatively small tubes.

I was interested in Mr. Funk's discussion. It seems to me he rather subscribes to the foregoing suggestion. I, too, have heard of tube leaks in extra high pressure boilers, where not only does a small leak grow quickly into a serious one, but also allows the squirting water to bore holes in neighboring tubes.

The Use of Exhaust Steam for Process Work in Textile Plants

By SAMUEL M. GREEN
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STEAM delivered by power apparatus at or above atmospheric pressure is usually termed exhaust steam. Such steam has been used for many years successfully for textile finishing or process work. It is impossible to lay down general rules that will cover the question whether or not power should be generated in a textile finishing plant as no two plants are alike in size, use of steam, power, or methods of finishing.

Textile process work, or finishing, covers bleachings, dyeing, printing and preparing the surfaces and textures of fabrics and yarns to meet various market conditions. All of the innumerable processes require heat at some stage and 98% of the heat required is furnished by steam at or below 20 lbs. gauge pressure. Therefore, exhaust steam may be economically used where power is required in sufficient amount to warrant installation of power equipment.

Finishing plants have been operated for many years by large engines driving line shafting and by numerous small engines driving machines requiring variable speeds, such as dry cans, tenter frames, printing machines, etc. The exhaust from these engines is used for process work but, in many instances, there is more exhaust steam than can be used because of the very large amount of steam used by the small engines. A recent test made on such an engine, which was in fairly good condition, showed that 150 lbs. of steam were being used per I. H. P.

It is evident that the engine driven plant requires a high and low pressure steam pipe system and, as plants grow, these systems become complicated, inefficient, difficult and expensive to maintain and change. Engine drives are being replaced by steam turbines and electric motors, as the use of such apparatus, in their present highly developed state, re-

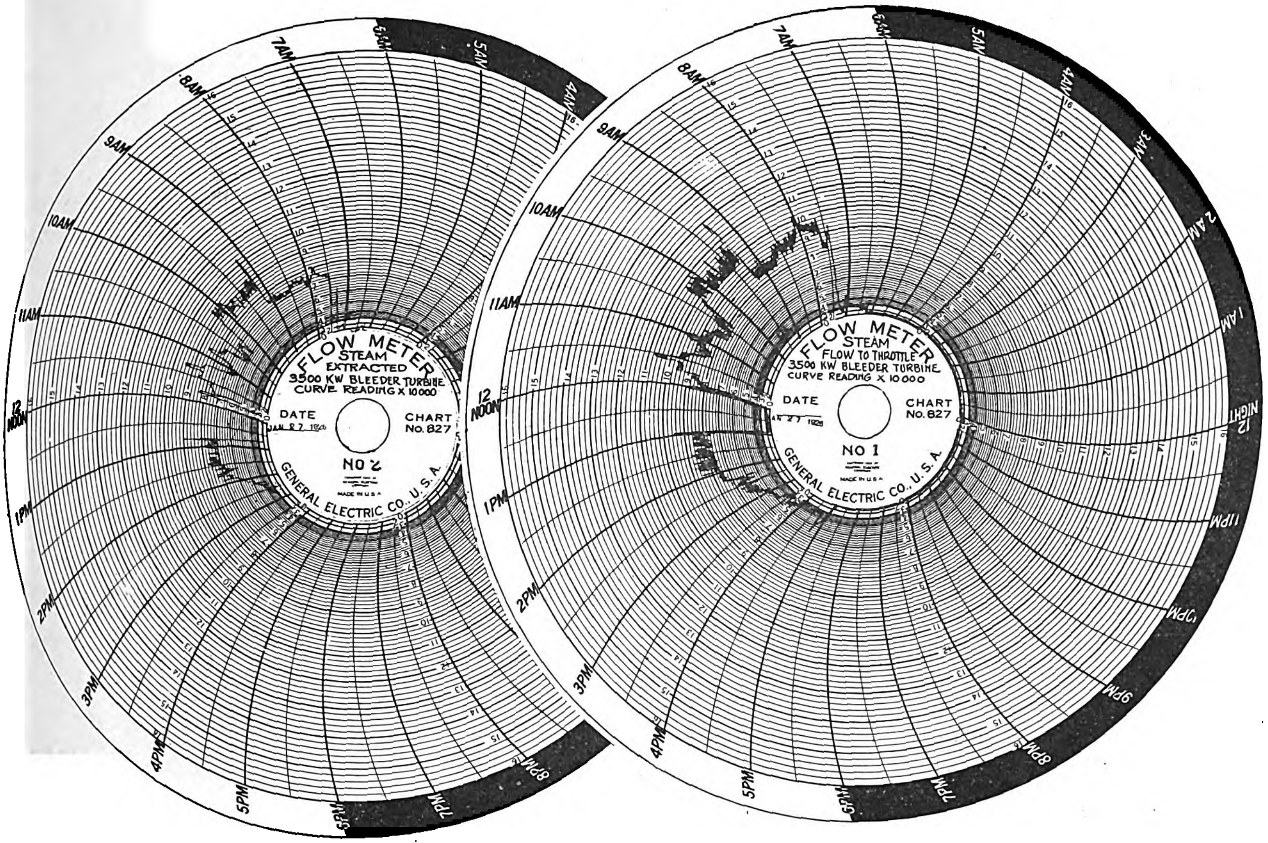

FIGURE 1

sults in more satisfactory operation and large steam saving. There is no method of producing power as economically as by the use of a steam turbine, if all the steam passing through it can be used for heating.

In general, the steam required by any textile finishing plant for process work will, if passed through properly designed power apparatus, generate more power than is required for finishing. In cases where the demand for process steam always exceeds the amount of steam required to produce the necessary power, back pressure turbines should be used. Such turbines will require from 35 to 50 lbs. of steam per KW hour and approximately 92% of the heat in the steam will be available for process work and 8% will be used to produce the power. The efficiency depends upon the initial and final steam pressures and size of the turbine.

If a finishing plant required an average of 400 KW and 25,000 lbs. of steam per hour for 8 hours per day, with an efficient boiler plant carrying 175 lbs. steam pressure and using coal at $6.00 per net ton, a turbine would produce power at .8c per KW hour. This cost includes fuel, wages and interest and depreciation at 12½% on turbine investment.

In cases where the demand for process steam exceeds the amount of steam required to produce the necessary power for a portion of the day and for the rest of the day the process steam required is less than that required for power, bleeder or extraction type turbines should be used. This type operates with a condenser. Such turbines are arranged so that all or any portion of the steam flowing to the turbine may be extracted at any predetermined pressure above atmosphere. When all of the steam required for power is extracted, they operate practically as a back pressure turbine, only a small amount of steam flowing to the condenser. When less steam than is required to produce the power is being extracted, then sufficient steam in addition to the extracted steam flows to the condenser. A turbine of this type when operating with no steam being extracted operates at the same efficiency as a condensing turbine.

A Recent Installation

The steam guarantees of a 3500 KW turbine that I have recently installed in a finishing plant follow: The steam conditions are 225 lbs. steam pressure, 100° F. superheat, 15 lbs. extraction pressure, 2" absolute condenser pressure.

When operating condensing, no steam being extracted, the guarantees are: at 3500 KW load, 14.9 lbs. of steam per KW hour; at 1750 KW load, 15.8 lbs. of steam per KW hour.

The maximum amount of steam that may be extracted and the total amount of steam flowing to the throttle are: at 3500 KW load, extracted 122,000 lbs.,

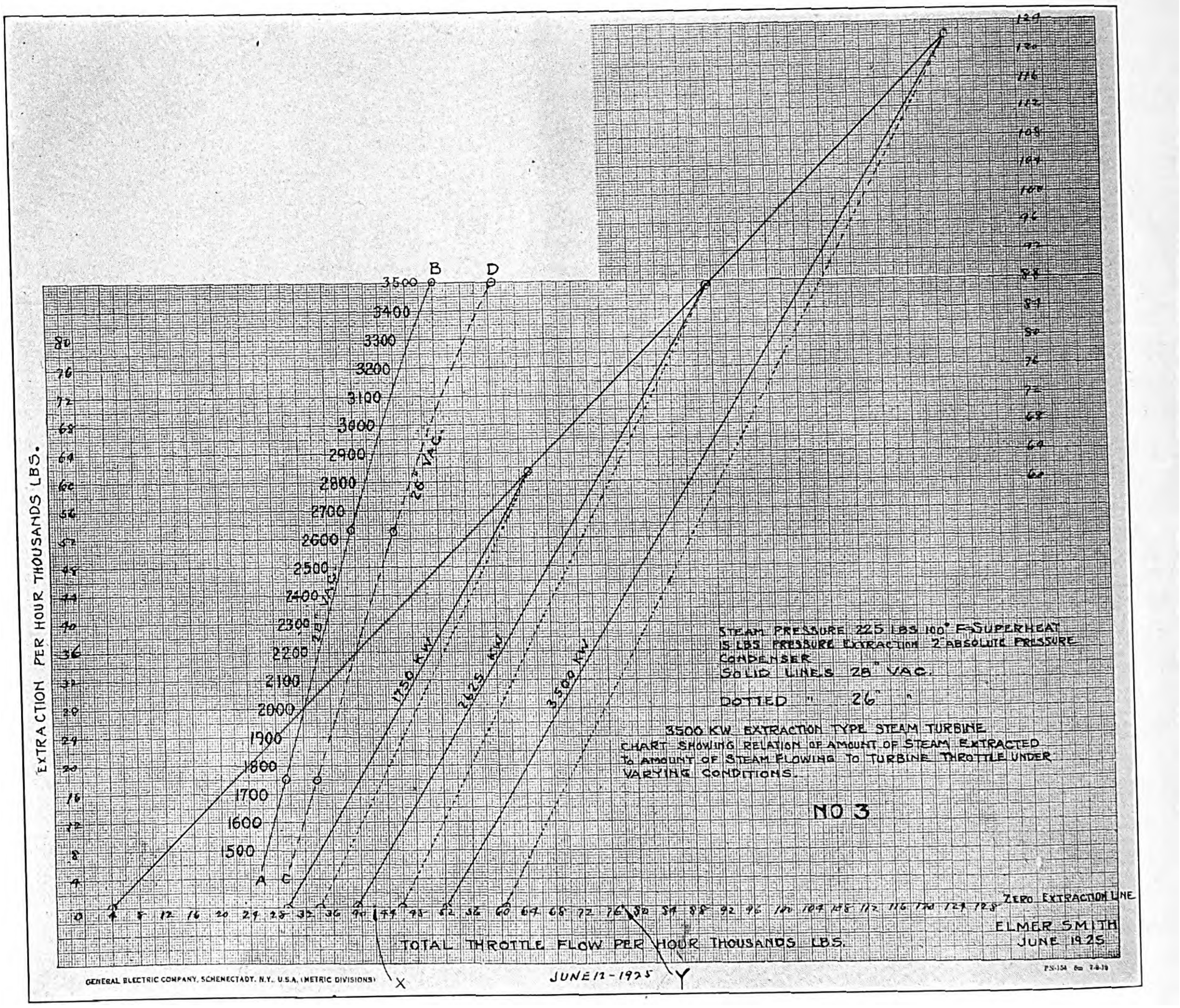

FIGURE 2

to throttle 126,000 lbs.; at 1750 KW load, extracted 61,400 lbs., to throttle 65,400 lbs.

Under maximum extraction conditions, only 4,000 lbs. of steam flows to the condenser and this produces power at a steam rate of about 16 lbs. per KW hour.

Steam meter charts showing steam flowing to the throttle and being extracted from this turbine are numbered 1 and 2 (Fig. 1).

Chart No. 3 (Fig. 2) was furnished by the turbine manufacturers and from it the amount of steam required at the turbine throttle under varying loads and steam extraction conditions can be determined. The chart is based on 225 lbs. steam pressure at throttle, 100° F. superheat, 15 lbs. extraction pressure and 2" or other absolute pressure. The left hand vertical column of figures shows the amount of steam being extracted from the turbine, as read by a steam meter properly corrected for errors or correction factors. Line A-B is a line based on 28" of vacuum and the figures next to this line, on the left hand side, are kilowatt loads being delivered. The dotted line, lettered C-D, gives the same data for 26" of vacuum.

These lines are produced for the purpose of determining the point at which to start on the horizontal line just above the bottom of the chart, called "Zero Extraction Line." For instance: to determine a starting point on the basis of 60,000 lbs. being extracted, 2800 KW load and 28" of vacuum, follow out the line horizontally figured 60 on the left hand column to its intersection with line A-B. Drop vertically to zero extraction line, which will show a point 41,600, marked "X" on the chart. Then draw a line parallel with the solid line marked "2625 KW" to the intersection with the 60,000 extraction line. Then drop vertically to the zero extraction line and this will give the total steam flowing to the turbine, which under this particular condition is 77,200, marked "Y" on chart.

Under these conditions, 60,000 lbs. of steam are being extracted and 17,200 lbs. flow to condenser.

The steam flowing to the condenser generates power at about 15 lbs. of steam per KW hour or 1140 KW. The extracted steam generates at the rate of 36 lbs. per KW hour. The steam used for power is 17,200 lbs. flowing to condenser and about 8% of the extracted steam, 4,800 lbs.—a total of 22,000 lbs., producing 2800 KW at the rate of about 8 lbs. of steam per KW hour.

Large amounts of hot water are required for process work at this plant. The condensing water is taken from the condenser of the 3500 KW turbine and is passed through a surface condenser, into which a 1600 KW turbine exhausts, and is delivered into a 150,000 gallon insulated storage tank, from which the plant is supplied.

The 1600 KW turbine runs in synchronism with the 3500 KW turbine and the load carried by it is regulated in accordance with hot water demand. A vacuum of 5″ is carried on the 1600 KW condenser. The temperature of water flowing to the storage tank is regulated by an automatic valve and maintained at approximately 180° F.

A vacuum of 28″ is carried in the 3500 KW condenser as long as the steam flowing to the condenser does not require more condensing water than can be used in the plant. When that point is reached, the vacuum is dropped to 26″ which greatly reduces the amount of condensing water required and thus saves heat which would otherwise be wasted.

About 700 KW is used by the finishing plant and 3500 KW is used by the manufacturing plant which makes the goods to be finished. The finishing plant's maximum steam demand is about 230,000 lbs. per hour.

The hot water is used for washing fabrics and there has recently been installed apparatus for recovering the heat from the waste hot water. This apparatus is known as a heat exchanger. It is guaranteed to cool water at the rate of 350 gallons per minute from a temperature of 210° F. to a temperature of 90° F. while heating fresh water at the rate of 400 gallons per minute from an entering temperature of 70° F. to a final temperature of 175° F. Operating under these conditions, 349,000 B. T. U. per minute are recovered, which is equivalent to about 20,000 lbs. of steam per hour.

Much of the steam used in finishing is for the purpose of removing water from fabrics and dry cans are principally used for this purpose. Dry cans are usually equipped with internal buckets for removing the condensed steam. There are usually a number of cans in vertical or horizontal rows, each can being piped to a header and this header to a single trap. With this system, the air and gases in the steam are not readily removed as there is no circulation through each individual can. A system for removal of condensation, consisting of siphon pipes and individual traps attached to each can, has been installed in many plants in the last few years and this system seems to produce more economical results than the bucket system. A number of tests have been made by one of my clients to determine the amount of steam being used to dry cloths before and after equipping the cans with the siphon system. These tests show that the siphon system saves about 18% of the steam required by the ordinary bucket system.

In many dyeing processes, the dye liquor is boiled by steam blown into the liquor through perforated pipes. Many dye houses carry at least 80 lbs. steam pressure to the dyeing kettles and the flow to the kettles is regulated by a hand operated valve.

Before installing the turbine of which I have spoken, it was necessary to convince the superintendent and foremen of the plant that 12 to 15 lbs. steam pressure would dye goods as well as 80 lbs. steam pressure which they had used for many years.

This dye house uses a large number of dye kettles for dyeing cloths in the piece. The kettle consists of a tank, above which is mounted a large drum arranged so that it can be revolved. The kettle is divided into a number of compartments by perforated partitions, and across the front of the kettle is a perforated partition forming an open space between the partition and the front of the kettle. In this space, near the bottom of the kettle, a perforated pipe is placed, through which steam is introduced to boil the liquor. Cloth to be dyed is introduced into the kettle in long length, passing over the drum above the kettle, and lies in folds in each compartment. Each piece is made endless and when the drum is revolved the pieces are drawn from the front of each compartment over the drum and fall into the back of the compartments in folds. The top of the kettle is boxed in except at the front, and this box is vented by a 36″ duct through the roof to remove the steam. During the dyeing operation, the liquor is kept boiling and the cloth is constantly revolved by means of the drum.

When 80 lbs. pressure mains supplied steam to the kettles, the kettle operator regulated the boiling by adjusting a hand valve and always kept the liquor boiling violently as he was perfectly sure that the kettle was boiling if he saw liquor slopping over the front of the kettle.

I was given one kettle to experiment with to demonstrate the feasibility of the use of 15 lbs. pressure steam. It was necessary to bring the liquor to the boiling point in the same time with 15 lbs. pressure as with 80 lbs. pressure, as the daily production depended upon this. Therefore, the steam pipe leading to, and the perforated pipe in, the kettle were enlarged. A pressure reducing valve was installed to maintain 15 lbs. pressure on the steam supply to this kettle and a steam flow meter was used to measure the steam.

Before the piping system was changed, a long series of tests were made to determine the amount of steam used when operating from 80 lbs. pressure main and with the regular hand control. Temperatures were taken at the bottom and back of the kettle and it was found that, when the kettle was boiling violently, the temperature at these points varied from 206° to

209° F., and when moderately boiled from 203° F. to 206° F. With violent boiling, the 36" vent pipe to the atmosphere had to be kept open in order to remove the steam and with moderate boil this vent could be closed to one-quarter its full area. In order to eliminate variations in boiling due to hand control, an automatic steam valve with thermostat was installed, the thermostatic element being placed at the bottom and near the rear of the kettle, and it was adjusted to open the steam valve wide when the temperature was at 202° F. and close it at 206° F.

Tests covered a period of four months and it was definitely shown that with 15 lbs. steam pressure and automatic steam control dyeing was more uniform and at least 25% less steam was used during the boiling periods. The superintendent and foremen are now advocates of low pressure steam and automatic control. There are 60 dye kettles in this plant now supplied from steam mains carrying 15 lbs. pressure, with automatic steam controls which operate satisfactorily.

In dyeing plants, difficulty is experienced with condensation collecting on the roof of the buildings because of the large amount of vapor caused by boiling liquors and drying the fabrics. The only successful method of eliminating this difficulty is to blow hot air into the rooms and this requires a large amount of steam to heat the air.

In the paper industry, the water evaporated in drying the paper is collected through ducts and blown through an economizer and fresh air is drawn through it to the steam air heater. The fresh air absorbs the latent heat in the steam collected over the paper machines. This device has proved very effective in assisting to heat the air necessary for the absorption of the moisture in the paper machine rooms. In one comparatively small plant, the introduction of such a system saved approximately 100 boiler h. p. In my opinion, such devices may be economically applied to dye houses.

Each finishing plant has its own particular problems, but I believe that a proper investigation of any plant will show that steam may be saved in amounts to warrant such investigation.

(Will be continued in July issue)

Seeking Better Way of Designating Oils

Viscosity is the most important property by which the suitability of an oil for lubricating an internal combustion engine can be determined, but the viscosity changes greatly with changes of temperature and also with the amount of dilution of the oil in the engine by unburned fuel. The temperature of the oil in the crankcase may vary from below zero to 212 deg. Fahr., and the dilution may vary from practically nothing to a very high percentage. The average amount of dilution in the United States probably is about 15 per cent in summer and 25 per cent in winter.

There is real need of a standard system of designating oils of different properties that will enable the automobile engineers to recommend oils that are suitable for use in the engines they design and so that the public can buy oils of the grades recommended by the automobile builders. Committees representing the Society of Automotive Engineers and the American Society for Testing Materials are now working on this problem, but their work will be of no avail unless the oil companies will mark their oils by some recognized standard system.

H. C. Dickinson, of the Bureau of Standards, has suggested that the viscosity of oils should be compared at a given temperature and the viscosity grade be indicated by numbers instead of by the words "light," "medium," "heavy" and so on. A sub-committee of the A. S. T. M. suggested a test temperature of 130 deg. Fahr. for comparing the viscosities of low-viscosity oils ordinarily used in automobiles and 210 deg. Fahr. for high-viscosity oils ordinarily used in trucks and tractors. By taking numbers representing one-tenth of the viscosity at 130 deg. and the actual viscosity at 210 deg., a series of numbers, in an increasing order, would be obtained that could be used to represent the viscosity. This would not interfere with any trade names or the names "light," "medium" or "heavy" that are used now by the oil companies.

This suggested system is not intended to replace the system of "purchasing agents' specifications" now in use by both the refiners and the vehicle builders but to enable the vehicle owner to obtain oil of the proper grade or viscosity.

—*H. C. Mongey, Chief Chemist, General Motors Corpn., in Journal of S. A. E.*

Electric Railways

A useful study to all interested in street railways is the compilation recently made by the American Electric Railway Association, Bulletin No. 56. Its full title is sufficiently descriptive of its contents:—"Public Ownership and Operation of Electric Railways"; being a compilation and summary of the outstanding facts concerning the public acquisition and operation of electric railways, including a list of *all* publicly owned or operated railways, a history of the events leading up to their public acquisition, the terms on which they were taken over and the statistical data on the results of their operation under public management. Part I. United States. Thirty-four railways are described, including the lines on Staten Island, privately owned and publicly operated, and New York's Subways which are publicly owned and privately operated.

Aero-Transportation

A Discussion Held Under the Auspices of

The Engineers Club of Philadelphia

March 16, 1926

(*Continued from page 141 of the May issue*)

Heavier Than Air Craft

By WILLIAM BUSHNELL STOUT

Mr. Stout, a graduate of the University of Michigan, later a designer of automobiles, Chief Engineer of the Air Craft Division of the Packard Motor Car Company, Technical Advisor of the Air Craft Board in Washington, designer of all metal planes for the Navy, is now of the Air Line Division of the Ford Motor Company.

IN any problem—and the solving of it—there are three stages: First, what to do; second, how to do it; third, the doing of it.

Aviation today is chiefly concerned in studying the first part of that need—**what to do.**

Commercial aviation has some entirely different aspects from the former military activities of the flying machine, in that a commercial airplane is one that must support itself in the air financially as well as mechanically. When you visualize the difference between a machine that will just fly, and a machine that will support itself in the air and earn a dividend—support itself financially and earn a dividend under the widest range of conditions—you have the difference between a military plane and a commercial plane.

Every element aimed at in the commercial plane is different from what is desired in the military; and yet the same fundamental engineering is used in both types of planes. All that has been developed in connection with working out the design of military planes is available in the development and building up of commercial air craft.

In the aviation business we get a great many inquiries from boys. They are young men who want to get in the airplane business while it is young, so they can grow up with it. That always gets a little smile out of me, when I think of Glenn Martin and some of the rest of us, because we were young men ourselves when we began to think about this thing. When the Wright brothers first flew the airplane, Mr. Ford's production was a few cars per week. The automobile business had hardly been born when the airplane business began, or rather when the airplane was invented. The airplane is almost as old as the automobile, yet they build several automobiles a day now, and it is a commercially recognized industry, and has been the means of building up more wealth in this world than has ever existed in any other period of its history. But the airplane is still fooling around to see where it is going to land; and we all wonder what it is all about.

The men who come asking for jobs—to get into this business, when there isn't any yet—mostly have an engineering picture in their minds. They say, "Well, cannot we go to some college and learn to be airplane engineers?" I think probably you could say that up to this time we have had too many engineers and not enough business men. I think if you cite the list of those of us who have been in it for many years, the public will recognize us as the old original gang of "nuts"—and anybody crazy enough to be in the airplane business ten or fifteen years ago had to be a "nut." Some of us hope we have grown out of it, but we are not quite sure yet. However, we are getting to a point where we begin to see daylight, where we begin to see something coming which is really tangible, and which can be built into an industry.

One of the fundamental difficulties has been in getting the public to see what an airplane is. And I would say frankly, to those who do not fly, that if aviation was what you think it is, we fellows would not be damn fools enough to be in it—pardon my language, but that is the statement. If flying were the risky, dangerous thing that it looks to be, then none of us would be in it—we would go into some other occupation, such as that of a hobo. You know, everybody is as suspicious of an airplane as he is of a hobo, for it has no visible means of support. And there is an actual feeling on the part of the public, when they see an airplane floating along up above, that it is likely to fall any minute.

But at that, I have been thinking recently that the airplane business is getting to be pretty risky. One of our pilots, coming in from the field one night, ran into a farmer's wagon with his automobile, and broke his arm. Another fellow came down to work with us, got a little bug in his ear, and went to the hospital for a mastoid operation. Another is in bed with pneumonia. Our factory superintendent, walking between two buildings the other day, slipped on the ice—he went to the hospital with his shoulder dislocated. So the airplane business is getting to be mighty risky. At the same time we have been running airplanes on our line between Chicago and Detroit, Detroit and Cleveland, every day, with one thousand to fifteen hundred pounds of freight on each trip, two trips a day, to Cleveland, three to Chicago, covering more than ten times the distance around the world during that time; yet have not had a single casualty of any kind.

At any rate, about the safest place is getting to be in the air—you are not half as likely to slip as you are down on the ground.

Really, the first problem that must be solved before you can begin air activity is the problem of getting a plane—a plane that will fit the requirements of the type of service you are going to give. So far, this country has been limited to the use of left-over war planes, mostly training planes. Now, no one in the world would claim that you could take a two-seater plane designed I don't know how many years ago, and call that a commercial plane. Yet by the application of good business instincts a lot of pilots have taken those planes and placed themselves where those ships can be used commercially and pay dividends; but the types of activity they can serve are very limited. Every new type of plane we put out will open up a whole new field for aviation. Every new size that is put on the market, each different capacity or speed range, will find its particular place where it will fit. But the basic reason why we have had none of these developments is that we have had no engine.

We had the OX-5, designed before the war, and a marvelous engine for its day; and we had the Liberty engine, of 90 and 400 horsepower—nothing else. What is the use of designing a ship if there is no engine to go in it? Firms have come out with engines for the Government that we could have purchased at $15,000 apiece; but that is not a commercial engine. You cannot blame the manufacturing companies, because there is not production enough to get that price down; and you cannot expect them to sell engines on a charity basis. So we have been working around in a circle.

You cannot start production of planes of large size without the price being high, therefore commercial aviation is going to come first with planes built and sold to corporations on the basis of *earning capacity*, for use on air lines. Whether the industry is going to go into the selling of airplanes for commercial use on the basis of what dividends they are going to pay, or of small ships with small engines for the private owners, whether that is going to be the big end of the business, is all an open question. It depends so much on the vision the different groups show, and where they put their experimental and financial effort. And it depends so much on the psychology of the public, on the politics of the situation, on what type of restrictive laws are passed, so it is impossible to foretell.

It is probable that commercial planes for air line work will grow larger and larger. There will be multiple engines and devices by which one can make sure that there will be no forced landings between terminals for mechanical reasons. Those things will come when we get to carrying passengers; but there is one thing that is bound to dominate all that situation, and the privately-owned planes as well, if the firms concerned have vision enough to take the thing up before it is too late; and I refer to the insurance business. Today the insurance companies are dormant. They are, to my notion, missing the biggest bet in the business. They are letting the Government take over the business of licensing and inspection of aircraft. That should be under a commercial jurisdiction rather than a governmental jurisdiction. That should be dominated by a dollars and cents angle, a commercial angle, rather than by a political angle; and while I agree with the statements that have been made regarding the legislation on airways, the legislation on passenger traffic by common carriers, yet I am very much afraid that if that applies to the privately-owned ship, and if it is carried too far in the common carrier idea, that angles will enter into the construction of ships and into their operation which are political—to please the public. While I do not wish in any way to take sides with any generals or others I think all fliers will stay with me when I say that an air service must be operated by air men, who can think in three dimensions.

There are so many conditions where the man on the ground is perfectly sure the thing is simple, while to the pilot—he knows it is not feasible. And there are conditions where the man on the ground would say, "That is not possible," but the pilot would not hesitate a minute to do it. He knows the conditions and the man on the ground does not, no matter how he may flatter himself on his vision. If you cannot live in three dimensions, you cannot have any technical knowledge of air transportation.

I could not help mentioning that one angle of legislation, where I believe the insurance companies should see their opportunity; for, by meeting the industry half way, they can solve the problem much better than it can be solved by Government supervision, because if your insurance is going to be good for the airplane you are going to see, before you go up in that plane, that it has in the cabin the sticker which says the Underwriters' Association approves of it, the same as you do when you ride in an elevator in this building.

I don't want to be misunderstood when I question that Government angle. I am not speaking of anything except the type of organization and the method in which it has to move. I agree thoroughly with what Mr. Keys has said*—that the personnel which is working through the Government departments on this aviation proposition cannot be criticized; and the general I mentioned before, I think, also makes that statement. But some higher ups are not helping to boost aviation as they should.

It would help so much if some of these things could be solved—when it comes to commercial aviation—through the insurance company angle, or a civilian angle, rather than by making it a Governmental function. So that, if we could have the insurance companies checking our engineering, as we design and build planes, we would have a business organization to deal with, and a control with a much more definite connection with the industry, than by the laws which are proposed at the present time.

Beside the above problems, I have mentioned the engine problem. One of the most hopeful indications in regard to the whole matter just now is that there are so many engine projects under way; and some of you may be surprised to know that of all of them I don't know of a single one of the new projects that is not air-cooled. It has always seemed to me that it was just as foolish to water-cool an airplane as to air-cool a motorboat. In airplane engines, the tendency is all that way. If you were in a machine up in the air, going a hundred miles an hour, and could feel that "stuff" going by, you would think it was enough to cool an engine. The air, at that speed, has enough "stuff" in it. So that air-cooling is becoming almost standard—in the experimental laboratory at least.

Each new engine will create a new series of planes around it. The engines will run from 25 horsepower to 1,000, and each company will have its own idea as to where they are going to fit. One of the most hopeful things is the fact that these firms, and others that will be under way, are going into the airplane engine business with real money, with real knowledge of what they are tackling, and with real ideas for solving the problems.

There is one group operating that I look to as the real nucleus of aviation, and that is the group of pilots who have sacrificed all these years, and the chaps who have been taking what they had and making dividends out of it, rather than painting great pictures of the future—which we all like to do. And they are quietly working down in Kansas—and out in that Western part of the country, west of the Mississippi mostly, there have been a lot of these fliers. We checked about fifteen hundred airplanes. And those planes have been doing remarkable work. And those are the kind of planes we have been talking about regulating out of existence. Yet in spite of the hundreds of thousands of miles flown, the accidents have been almost negligible.

Planes now are cheaper to build, perhaps, and are built around the old OX-5; and some of the newer ships are coming out in increasing quantities, such as Waco, Travel Air, Swallow and Laird. Waco is turning out three planes a week, and is more than three months behind its orders. What they are trying to do is to make better ships for less money.

So that, the two-fold air-line operation, and operation by private owners, are the next two problems. Therefore, if we can find out just what to do to fit those two fields, we will be in the next stage.

So far as Mr. Ford's operation of air lines is concerned, the rule all the way through is that it is purely experimental. He is trying to find out what it is all about. He is watching it very closely. He is far more interested in it than the public knows and he is spending a great deal of his own time at it, educating himself as to what is going on. The moves that will be made nobody knows. He never makes a plan. When the time comes he will decide, not before. And it may go this way or that way, but you can bank on it that it will go forward, but in what direction will depend entirely on the developments, as things grow of themselves. The issue will not be up to us. The air lines are running, so we can find out *what we need to do* more than anything else. There are things we should not do. We want to find out what those are. And just like the way you are learning, we have learned a lot of things. Some things we have done wrong, like putting the lights in the wrong places, but the experience has been valuable, and it is available to anyone who wants to use it.

I would not entirely recommend all the cost figures, because at the present time the firm is not interested in that angle. They first want to know if they can give the service, if the planes will run regularly and can deliver their load under all conditions of weather and problems of personnel. After they learn what type of service can be made to pay, the work will go on from that point.

We are not competing with other kinds of transportation. We go where other kinds cannot go, rather than on the time basis, but even that may be temporary.

So the only message I would want to leave, as to what we are trying to do, is that thought—that we are trying to learn all the lessons we can about aviation, in all its aspects; and if we learn anything that is of value to you, it is available to you any time And at the same time we may come to you and ask you a lot of questions, to see if you know anything we don't know, and we will exchange when we can. I thank you.

(Will be continued in July issue)

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*See May issue ENGINEERS AND ENGINEERING.

The Oil-Electric Locomotive

From an interview with

C. H. OUTERBRIDGE

Former Chairman, Port Authority of New York

THERE is perhaps no other single factor in industrial life throughout the world today so much in men's minds, so important and potentially so beneficial in its results as economy in productive effort. It is a well-known axiom that capital is created only out of savings and it is increasingly true that profits and prosperity are dependent upon a continuous development of economy in productive effort, whether it be in the unit of man-power, of machine work or of administration.

There is perhaps no other single field in which this principle is as vital as in the production of power. Super-power organization has become a topic of almost daily comment in the public press and great strides towards its accomplishment have already been made. The vision and courage of men bring these things to pass, but economic law and necessity is the underlying force which spurs men to invention and accomplishment and gives the owners of capital the confidence to employ it in such developments. In the United States, because of the extent of its territory and its industrial development, the use of power for railroad transportation is vitally important.

For a number of years past much has been heard in the Marine field of a new form of power which has been rapidly growing and supplanting the former types of reciprocating and the later types of turbine steam engines. I refer to the well-known Diesel type of oil burning engine.

In still more recent times, within only the past few years, invention has made it possible to build oil-burning engines of much lighter weight per horse power, and therefore of less cost, than formerly. This principle has now been successfully applied in the development of what is known as the OIL-ELECTRIC LOCOMOTIVE.

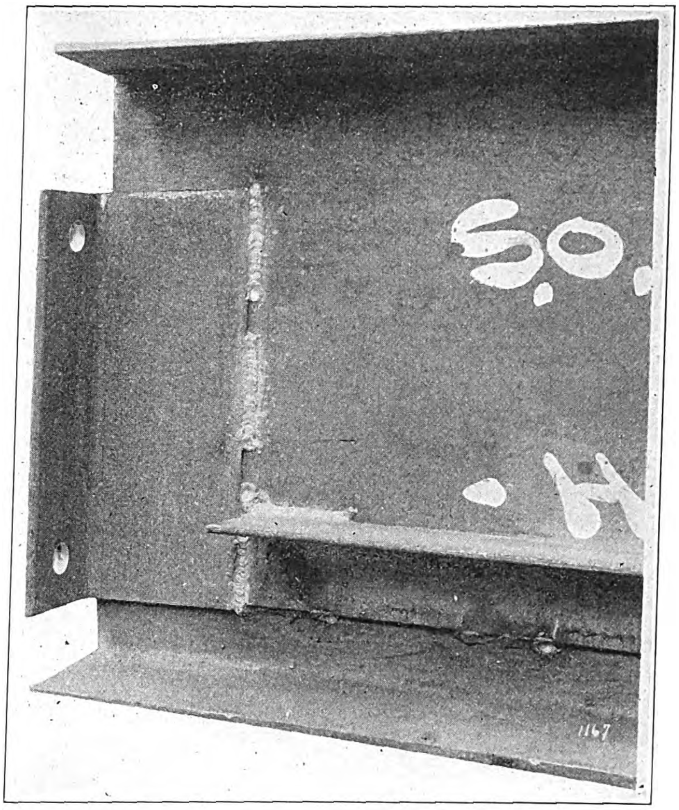
It is not my purpose and I am not qualified to enter into any technical description of this latest product of invention and science. Up to the limit of size and power so far produced, demonstrations have already been given which have so convinced the best experts in railroad operation of its economy and usefulness for certain fields and character of employment, that numbers of these engines have already been ordered. It is always ready to go, no time is lost in getting up steam, no waste in blowing off, or in banking fires. If its development in higher power units than as yet produced gives equally favorable results for long distance hauls, it will challenge the attention of railroad operating men wherever the steam locomotive is now the main dependence.

If, as I believe, the draught efficiency of this engine per unit cost of fuel per ton moved greatly exceeds that of the steam locomotive, it would seem as if the oil-electric engine has the potential future of supplanting the present type of steam locomotive, as fast as the railroads can afford to scrap them.

There is, however, on the other side of this question an important consideration which may place some limitation upon the future of this invention. That question is the quantity and permanency of the supply of fuel oil if a vast and rapid increase in the use of the oil-electric engine should ensue and, the effect of such increased demand upon the price of oil. Judging from recent reports in the public press experts differ vastly in their estimates of the oil supply. Some insist that it is capable of great expansion and of supplying all possible needs for generations to come. Others state that in a few years the available supply will begin to rapidly decline. With the enterprise of oil prospectors and operators it seems fair to assume that they will discover and develop new sources of supply as rapidly as it will be mechanically possible to produce the oil-electric engine in sufficient quantities to seriously affect the oil situation.

The whole transportation world will watch the exploits of the oil-electric locomotive within the next tew years. Without doubt it is a great contribution and has come to stay. Time only can tell whether it will become paramount.

Welded Connections Used in Steel Building



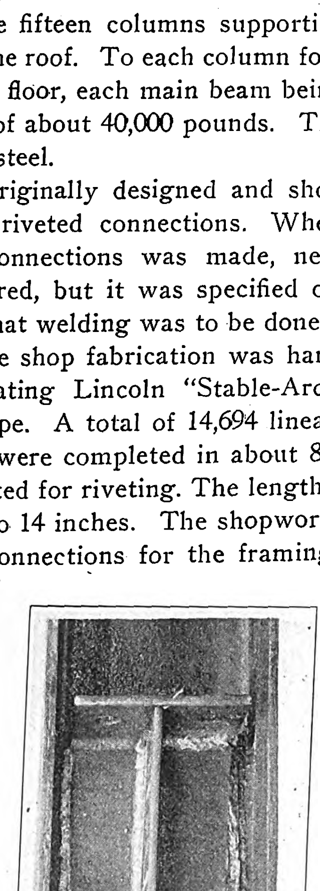
IN a building recently erected at Canton, Ohio, electric arc welding has been used throughout for connection of the steelwork. The operation is said to be of greater magnitude than any previous similar job of welding.

The building is a two story and basement structure to serve as an automobile sales, service and storage plant. It has a frontage of 150 feet on one street and 100 feet on another. The architect's specifications provided for a live load of 90 pounds per square foot and a dead load of 40 pounds per square foot. Columns are 8 in. H sections and the beams are 12 in. I's. There are fifteen columns supporting the two main floors and the roof. To each column four beams are framed at each floor, each main beam being designed to carry a load of about 40,000 pounds. The work involved 95 tons of steel.

The structure was originally designed and shop detailed plans made for riveted connections. When the change to welded connections was made, new drawings were not prepared, but it was specified on the original shop details that welding was to be done.

All the welding in the shop fabrication was handled by three men operating Lincoln "Stable-Arc" welders of the portable type. A total of 14,694 linear inches were required and were completed in about 80 percent of the time estimated for riveting. The lengths of welds varied from 2½ to 14 inches. The shopwork involved the welding of connections for the framing of beams to columns, of spandrel beam connections, for supporting the brick walls, angles for the windows, and shelf angles for supporting floor joists. In the erection of the steelwork 780 welds were made. One operator working with the same type of portable welder used in the shopwork made a total of 4,294 inches of welds in 120 working hours.

Although the steel was not designed especially for welding, only a small amount of overhead welding was required. The contractors state that this overhead welding could probably have been eliminated and that much welding and some material could have been saved if the plans had been redrawn for arc welding. Bars could have been substituted for angles in the seat connections on the columns. Plates could have been welded to the ends of the beams instead of the end connection angles or the beams could have been cut to neat length and welded directly to the columns.



Lower Shelf Angle Welded to Column

The contractor reports that substitution of welding for riveting resulted in important savings. Labor costs involved in fabrication were reduced 23 percent below those estimated for riveting. Savings in other trades are said to have been secured in erection because there was no interference with other classes of work as would have been the case had riveting gangs of four men each been employed.

Tests of welded connections made by the contractors and the manufacturers of welding equipment indicate that two linear inches of $\frac{5}{16}$ inch welding bead equals the shearing strength of a ¾ inch rivet. Two and a half inches was adopted as standard and most of the welds on the Canton job are actually three inches long, providing an additional factor of safety.

The Morgan Engineering Company of Alliance, Ohio, furnished the structural work and were responsible for the change from riveted to welded connections.

C. C.

NEW BOOKS

BOOK REVIEWS

A Handbook of Summer Camps—Second Edition, 1925. 765 pages, 4½x7. Cloth, $5.00.

Description of a thousand camps, with statistics and information regarding each. Well indexed. Useful as a basis for a general investigation of the subject.

A Handbook of American Private Schools—Ninth Edition, 1924-'25. 1,047 pages, 4½x7. Cloth, $6.00.

This is an annually issued directory useful for parents and educators. Very complete, well classified and indexed.

Mechanical Engineers' Handbook—By Lionel S. Marks, Professor of Mechanical Engineering, Harvard University, assisted by a staff of 59 specialists. 2,000 pages, flexible, 4½x7, thumb-indexed, over 1,000 illustrations and diagrams, $6.00 net, postpaid. Travelers' Edition (bound in three handy, pocket-size volumes, waterproof flexible Keratol covers, with separate index), per set, $8.00.

Here is a book which has long been recognized by engineers throughout industry as well-nigh indispensable, brought up to date and expanded until it represents the most modern and authoritative compilation of useful engineering knowledge so far published.

Highways and Highway Transportation—By George R. Chatburn, Professor of Applied Mechanics and Lecturer on Highway Engineering, in the University of Nebraska. $3.00.

The problem of our national highways becomes more and more acute as our civilization grows more complex. It is no longer an academic question, if it ever was such. The measure of our future safety, prosperity, and comfort is co-equal with our transportation facilities. This is but another way of saying that a book such as this is not only timely but deserves the earnest consideration of officials, lawmakers and citizens generally.

Scientific Management Since Taylor—A collection of authoritative papers and addresses, edited by Edward Eyre Hunt, Assistant to the Secretary of Commerce; Member, Committee of Elimination of Waste in Industry; Secretary, President's Conference on Unemployment. 260 pages, 6x9. $3.00.

Since 1914 there has been no formal effort to bring up to date in one place a record of the new developments and influences at work toward the reshaping, modifying and liberalizing of the idea embraced in Scientific Management. Now, with the consent and co-operation of the Taylor Society, Mr. Edward E. Hunt has made a selection of the most recent papers and addresses which serve to give an up-to-date picture of the present status both of the outlook and the procedure of Scientific Management.

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Portable Lamps. Principles of Design. Pedestals. Lamp-Shades. Uses in Various Rooms. Novelties. Light-Sources.

The Lighting Art: Its Practice and Possibilities. Broad Aspect of Lighting. Expressive Possibilities of Light. Visualization. Variety—the Spice of Lighting. Distribution of Light. Lighting Fixtures. Light and Color. Colored Illuminants. The Psycho-Physiology of Color. Simulating the Spectrum of Daylight. Application of Artificial Daylight. Some Applications of Colored Light. Simple Principles of Light-Control. Lighting and Architecture. Portable Lighting Unit. Residence Lighting. Commercial Lighting. Lighting in Public Buildings. Industrial Lighting. Stage Lighting. Spectacular Lighting. Computations and Data. Natural Lighting. Language of Color.

Color and Its Applications—6x9, 150 illustrations, 4 color plates, 34 tables, 431 pages. $4.50.

Light. Production of Color. Color-Mixture. Color Terminology. Analysis of Color. Color and Vision. Effect of Environment on Colors. Theories of Color Vision. Color Photometry. Color Photography. Color in Lighting. Color Effects for the Stage and Displays. Color Phenomena in Painting. Color Matching. Art of Mobile Color. Colored Media. Certain Physical Aspects and Data.

The above four books are by M. Luckiesh, Director of Lighting Research Laboratory, National Lamp Works, Nela Park, Cleveland.

Practical Steam, Hot Water Heating and Ventilation—By Alfred G. King. Fully illustrated by 400 detail illustrations, 551 pages, 6x9. $4.00.

Most complete and up-to-date work on this subject, and has been written for all engaged in the practice of Steam, Vapor, Hot Water Heating and Ventilation. The author has spent over thirty-five years in the heating trade and his experience covers every angle of the business.

ENGINEERS & ENGINEERING

JULY 15, 1926

Vol. XLIII FOUNDED 1879 No. 7

Business and Banking

THE general conclusion to be drawn from study of the conditions of the first half of this year, and the month of June in particular, is that business should be good for the balance of 1926. The producers of commodities, with only the textiles as an outstanding exception, and especially the fundamental industries such as transportation, agriculture, the manufacture of iron and steel, mining and banking, all return statements that prohibit the mild pessimistic belief that existed in the earlier months. There is seen, however, a tendency toward declining prices, and since there is little or nothing, other than the usual moderation that always comes with the vacation season, to prompt the belief that production may be materially lessened, it becomes evident that those who manufacture, as well as those who distribute, will carry on their businesses at less margin of profit than formerly. Consideration of these phases in detail develops the following:

The Textiles:

The business of manufacturing and selling cotton and woolen cloths has not been at a fair normal at any time this year, unless it may be that a radical change, instituted by those who inspire the fashions, and resulting in the consumption of a third to a half less than formerly of such goods as enter into women's clothing can be regarded as establishing a new normal. There is, in addition, a drift to artificial silks for many purposes that cottons have heretofore supplied, as well as an ability, on the part of the consumer more pronounced now than ever before, to use goods of silk in place of cotton and wool. An unofficial report estimates a cotton crop of 15,700,000 bales for this year, linters excluded, which approximates an average percentage condition of just under 78 to compare with just under 76 per cent of normal during the 1925 season. But there are said to be large stocks of last year's raw cotton on hand, unsold, and this, with the somewhat larger crop in prospect is without doubt the cause of reduced prices and a lessened production of manufactures.

Transportation:

Industrial activity logically is reflected in a heavier movement of merchandise and practically all railroads are reporting substantial increases in gross earnings for the later months of the half year. Not all of the coal carriers have yet made up their losses of revenue in the early weeks of the year, as a result of the coal strike, but the tendency is no doubt reflected in an average business increase of over 7.70 per cent for fifteen major steam lines during the period extending from and including the first week of February to the third week of June, of this year, in comparison with a like period of last year.

To be more specific, and to quote the Pennsylvania and New York Central systems as of largest interest here, it is found that during the first five months of 1926, the Net Income of the Pennsylvania was over 16 per cent ($4,818,517) more than during the first five months of 1925; while the New York Central reported that its business for May represented its best showing for any month this year, and the January to May period represented the highest earnings in the railroad's history. Many other trunk lines also report record business. In the study of this, consideration should be given to the fact that trolley systems and trucking enterprises—and especially those in Pennsylvania and New York Central territories, are moving more short haul and less-than-carload freight than ever before and this naturally is taken from what heretofore was carried by the steam lines.

Agriculture:

The President of the Chicago, Milwaukee & St. Paul, discussing the crop conditions of the territory traversed by his railroad, said that recent abundant rains have thoroughly soaked the dry districts in North and South Dakota and Montana, and the prospects are that they will radically change the whole situation. The dry spell in the spring damaged the early grain, and there was talk of shipping cattle out ahead of time; but the creeks and water holes are now filled and folks feel much better. In Texas and through the South and Southwest, there was some damage to all crops by excessive rains and high winds. For the country, however, there is indication of a wheat yield probably twenty-five per cent larger than last year, but still somewhat lower than an average of yearly yield.

Corn, in the middle of June, was said to need warmer weather and at the close of the month was said to be doing better. The general condition of all crops, as stated in the government estimate, was 76.5 per cent of normal up to last June, which compared with 79.7 per cent up to June 1925 and with 85.7 average per cent during the first half years of the past ten years.

Manufactures:

According to the Iron Age, June new business on the books of the steel mills exceeded in rate, the business of May. At the same time production has shown a moderate decrease, the operating percentage for the month being estimated at between 75 and 80. These conditions maintained to the end of the month will make a better showing than that of May, at least to the extent of a smaller reduction in unfilled orders, and a better balance between sales and delivery. Pig iron sales of the last full week of June made the buying movement the largest since that of November, 1924.

The position of the iron and steel industry has been improving for some weeks and its better status is indicated by advances in prices in some departments. To make production comparisons with 1925 would be striking an abnormal parallel because the steel output of 44,170,738 gross tons for last year made the high record of the industry.

The most notable gains in metal manufactures seem to be in automobile and electrical appliance production. The production of automobiles during the first five months of 1926 was well over two million vehicles or fourteen per cent more than during the first five months of 1925. During June, a number of new models were announced, mostly in small and moderate priced car types, and this, with some price reductions during June, undoubtedly has had the effect of accelerating demand.

The electrical industry will show somewhat less in total sales the first half of this year than last year, but manufacturers are busy. They see no prospect of falling off, but rather a steady business at the current rate throughout the balance of the twelve months. During June an order was placed for what is considered to be the world's largest turbo-generator unit, at a cost of around $1,750,000. The business condition is general, all sections of the country reporting about the same.

Building:

Building construction shows more activity than last year, with predominance undoubtedly along sounder lines than formerly. The home shortage is caught up, the urge to build in Florida lessened and the business of building is in more substantial condition than for some years. It is within the possibilities that there may be some over producton of office and apartment space in the cities, but up to now, nothing of the kind has been seriously felt.

391 of the larger soft wood and 149 of the chief hardwood mills of the country, reporting to the National Lumber Manufacturers' Association show apparently no great change in the activities of the lumber industry.

Mining:

The British Coal Strike is said to be responsible for an increased demand for West Virginia bituminous coal, which developed during the latter part of June. In other respects, the markets for bituminous and anthracite were dull.

There was likewise little change in the oil and gasoline business. There has been some falling off, or probably conservation, in the production of crude oil and there have been slight reductions in prices of motor grade gasoline and kerosene.

Banking:

The monetary situation is perhaps best reflected in the discount rate of the Federal Reserve Bank of New York, 3½ per cent, with no reason in sight to look for any early change. At the close of June, New York banks were lending at 4½ per cent for call loans and at 4¼ for 90 day paper.

According to the Commercial and Financial Chronicle, a total of $3,288,147,069 of new security issues were introduced in the United States during the five months ended May 31st, of which nearly three billions in par value represented new capital. And in this connection it is interesting to note that $175,372,000 of the figure shown above represented financing, in the United States, by foreign governments. Subsequent to the foregoing, there was readily absorbed here, an issue of $25,000,000 Government of Brazil 6½ per cent Bonds and an issue of $30,000,000 United Steel Works (of Germany) 6½s.

The market for investment bonds, known to be sound, is that prices are rising and dealers short of both large blocks and their customary variety of offerings.

A notable incident of the month of June was the announcement by the fiscal agent of Mexico that his government will resume the payment of interest on its external debt, represented by bonds held to a very considerable extent in the United States. Mexico originally defaulted these obligations in 1914. Past due interest is to be funded.

The stock market, during June, was erratic. For more than half the month, prices were rising; but during the latter half there was weakening and a fairly general decline which was somewhat out of place in the common expectation.

It is generally believed that money (good loans) will continue at low rates for an indefinite time. There will be variations, of course. Usually, money is cheapest in summer time, when it is in less demand by industry and business, and dearer in the fall when it flows from commercial centers into the country to finance the marketing of the harvests. But it is expected to remain cheap, comparatively. When securities yield a relatively larger return than loans, and conditions are such that it can be done, the country's money surplus, in the banks and elsewhere, logically goes into securities. And if the movement of good bonds and good stocks is not much the same, preference is bound to be given to that which yields the more, risk considered. So that it seems evident, if bond prices continue to rise and money conditions remain about as they are, investment stocks likewise will work upward. Nobody can foretell for any definite period of time, the course of price movements of stocks that are considered to be in the speculative class.

FREDERICK CARLES.

Items of Interest

Two Methods of Producing Ductile Welds

Two methods for producing ductile welds have been developed by research scientists working in different laboratories hundreds of miles apart. Both of the methods, similar in some respects, mark a decided step in the utilization of the heat of electric arcs in the joining of metal parts or the building of metal structures. The one was developed in the Schenectady research laboratory by Dr. Irving Langmuir; the other was developed in the Thomson research laboratory at Lynn, Mass., by Peter Alexander.

In both processes, air is excluded from the metal by means of a bath of hydrogen or other gas. The formation of oxides and nitrides in the weld metal is thus prevented, and the fused metal is as strong and ductile as the original metal.

Announcement of these radically new methods of arc welding are made in the March issue of the *General Electric Review*. In brief, the method developed by Dr. Langmuir in Schenectady is to pass a stream of hydrogen between two electrodes. The heat of the arc breaks up the hydrogen molecules into atoms. These combine again a short distance in front of the arc into molecules of the gas and, in so doing, liberate an enormous amount of heat, so that much higher temperatures can be obtained with this than with the usual welding methods. Since atomic hydrogen is a powerful reducing agent, it reduces any oxides which might otherwise form on the surface of the metal. Alloys containing chromium, aluminum, silicon or manganese can thus be welded without fluxes and without surface oxidation.

The process developed in the Lynn laboratory by Mr. Alexander is based on the utilization of the chemical and physical properties of hydrogen and other gases in their molecular state. This process aims primarily at the prevention of the formation of the nitrides and oxides in the arc-deposited metal, which limit the ductility of the usual arc welds.

In this process, the arc is struck between the metallic wire or carbon used as one electrode and the plate or work to be welded used as another electrode. The crater of the arc is always on the work to be welded. The gaseous atmosphere is supplied in the form of a stream around the arc. Pure hydrogen, water gas, hydrogen-nitrogen mixtures, anhydrous ammonia, methanol vapor and some other suitable gases can be used, according to the nature of the work. The hydrogen-carbon monoxide mixtures were suggested by Professor Elihu Thomson; water gas and methanol are examples of such mixtures.

This process makes arc welding more efficient and suitable for fields which at present are out of its reach. Low carbon steel, alloy steels, and most of the non-ferrous metals and alloys can be welded with success by this process in suitable gaseous mixtures.

Recently Published

Wind Bracing in Industrial and Many-Storied Buildings—By Robins Fleming.

Design of Details in Timber Structures—By Ray H. Lindgren.

—*Journal Boston Society of Civil Engineers.*

The Planning and Layout of Highways and the Economics of Highway Transportation.

The Development of Improved Highways—By Thos. H. MacDonald.

The Effect of the Development of Highways and Highway Transport on Other Transportation Agencies—By Henry E. Riggs.

Co-ordination of Rail and Highway Freight Transportation Within the Terminal Area—By F. J. Scarr.

Bus and Truck Regulation—By Dwight N. Lewis.

Capacity of Roadways—By R. F. Kelker, Jr.

Economics of Highway Transportation — By Henry R. Trumbower.

Placing the Bus in the Transportation Field—By Merrill B. Knox.

Financing Highway Construction and Maintenance—By Jacob Viner.

Safety Considerations in Highway Design—By Sidney J. Williams.

—*Journal Western Society of Engineers.*

A Ton of Coal Never Went So Far Before

Class I railroads in 1925 operated their freight trains with the greatest efficiency on record in the use of fuel, according to a tabulation of reports just filed by the carriers with the Interstate Commerce Commission and made public by the Bureau of Railway Economics.

An average of 159 pounds of fuel was required in 1925 to haul one thousand tons of freight and equipment, excluding locomotive and tender, a distance of one mile. This was the lowest average ever attained by the railroads since the compilation of these reports began in 1920.

The average for 1925 was a decrease of 11 pounds under that for 1924 and was 24 pounds less than that for 1923. The volume of freight moved by the railroads in 1925 was six per cent greater than in 1924 and was practically the same as that for 1923.

Metering Water Supply Grows With Population and Need of Conserving

The growth of metering water supplies in the United States in recent years has been due not only to education but also to changing conditions. Only unusual conditions make it now possible to furnish water "free as air."

With increase of population water is becoming less abundant and many cities find their supplies are limited and they are obliged to cut down waste. The necessity of purification is increasing and the need for it is more generally recognized. That adds to the cost of water.

The more general use of modern plumbing also has increased the burden of the water supply companies, for with a greater use comes greater waste. As a means of combatting waste and the spread of disease, there is every reason to believe that metering of water will become as universal as metering of gas and electricity.

—*Utility News.*

Defects in 70 Percent of Human Eyes Is Ascribed to Inadequate Lighting

More than seventy per cent of the eyes of adults in progressive countries have one or more defects. This is the result of increased demands on vision due to the advance of civilization.

"A backward glance readily discloses the reasons for defective eyes. Inexpensive controllable light has been suddenly thrust upon a civilization which for centuries had been used to flickering, feeble flames. In most progressive countries people read or do fine work under artificial light. It has been proved that eyes develop fewer defects under proper lighting conditions.

"We cannot think of the home without thinking of children. Their eyes are immature in growth and in function and are, therefore, very susceptible to injury and to malformation. Nearsightedness, eye strain, nervousness, and other disorders are results of inadequate and improper lighting."

—*Dr. M. Luckiesch.*

Personal Mention

C. G. Gaum has been elected Professor of Engineering Extension, Pennsylvania State College.

W. A. Sloan has been appointed an Assistant Professor of Mechanical Engineering, University of Pennsylvania.

T. P. Pendleton, formerly Chief, Section of Photographic Maps, U. S. Geological Survey, has joined the organization of Brock & Weymouth, Inc., of Philadelphia, to have charge of Plant Production of Aero-Topographic Maps.

F. E. Weymouth has suspended his work as active head of Brock & Weymouth, Inc., although he remains a Director and Consultant of the Company, and has been engaged by J. G. White Engineering Corporation as Chief Engineer for their work in Mexico.

Commander Hollis Cooley, U. S. N., has been transferred from Philadelphia to the Naval War College, Newport, R. I.

Lt. R. D. MacCart (CC) U. S. N., has been transferred from the Naval Aircraft Factory, Navy Yard, Philadelphia, to be Inspector of Naval Aircraft at the Curtiss Aeroplane & Motor Company, Inc., Buffalo, N. Y., which Company has a contract to build thirty-five fighter airplanes, F6C-3 model, for the Navy Department.

George H. Garrey, Mining Geologist and Engineer, who has been in Europe for the past five months has returned to his Philadelphia office.

Major L. E. Lyon, Corps of Engineers, U. S. Army, who for the past three years has been on duty with the 6th Engineers, at Camp Lewis, Wash., has been assigned to duty as District Engineer at Montgomery, Ala.

Aero-Transportation

A Discussion Held Under the Auspices of

The Engineers Club of Philadelphia

March 16, 1926

(*Continued from page 167 of the June issue*)

The Airship in War and Peace

By CAPTAIN GEORGE W. STEELE, U. S. A.

Captain Steele was in command of the Navy Patrol for a year, has had much experience with lighter than air machines, and was ordered abroad to superintend the later stages of the building of the Los Angeles, and came back with her. He is now in command of the Naval Air Station at Lakehurst, N. J.

THOSE who have in mind the wonderful achievement, in December, 1903, of the Wright brothers, will be surprised to learn that the art of flying in air craft lighter-than-air had its beginning in the eighteenth century.

The earliest record of a balloon ascension in which men were carried is that of the Montgolfier hot air balloon, which ascended at Paris in November, 1783, carrying two men. This balloon was of 100,000 cubic feet capacity, 86 feet high and 48 feet in diameter. The voyage lasted twenty minutes and covered about twenty miles. One month later a balloon filled with hydrogen ascended from the Tuileries Gardens carrying two pilots and remained aloft for about two hours.

The first balloon ascension in America was made at Philadelphia in January, 1793, in the presence of President Washington, by the French aeronaut, Blanchard. He made a successful landing near Woodbury, New Jersey.

In 1784 the Robert brothers tried the first elongated balloon, suspended from which was a wooden car provided with six silken oars and a rudder. By vigorous action of the oars they describe a curve of one kilometer radius and they considered the experiment a success. In 1852 Henri Giffard built an airship of 75,000 cubic feet volume. It was driven by a 3 H.P. steam engine and its trial was successful. In his efforts to raise money to build a larger airship, Giffard invented the injector for locomotives and realized several million francs from its sale, but before he could carry out his plan to build another airship his sight waned and never recovered.

The Early Rigids

In 1893, David Schwarz built a rigid aluminum airship in St. Petersburg, but it was damaged during inflation and was not flown. In 1895-1897 he built a metal-clad airship of 130,000 cubic feet gas capacity which was not internally subdivided. The envelope was made of sheet aluminum, 2 mm. in thickness. It was equipped with a 12 H. P. engine driving three propellers through belts. The ship was inflated by using cloth bags, which when filled with hydrogen were ripped and removed through the bottom of the hull. On November 3, 1897, the first flight started with one man on board, but the driving belts slipped off their pulleys and in the ensuing forced landing the ship was so badly damaged that it had to be dismantled.

Zeppelin and Santos Dumont both began their careers as airship builders in 1898, the former with rigid construction and the latter with non-rigid. The Lebaudy airship of 1899 was the first of the semi-rigid type.

The first flight of a Zeppelin airship took place in July, 1900, from a floating hangar on Lake Constance. The ship was of about 400,000 cubic feet gas capacity and had a speed of nearly 20 miles per hour.

The first Schütte-Lanz airship was completed in 1911. The framework was built up of girders of triangular cross section, and wood was used instead of metal. Among the features in those ships which have since been adopted by all designers were the streamlined form of hull, the arrangement and suspension of engine cars, the internal corridor, the single control surfaces, the propeller drive, and the accessible position of the automatic gas valves. The first airship in which the Zeppelin and Schütte-Lanz ideas were combined was built in 1916, and is the prototype of all later airships. In this model, wood construction was abandoned because it had been found that the glue in the laminations was too much affected by sea air. A total of 22 airships was built by the Schütte-Lanz Company.

Before 1914, nine Zeppelin airships were operated commercially. These ships were of 600,000 to

700,000 cubic feet gas capacity and made speeds of 43 to 48 miles per hour. The average length of their flights was from one and one-half to two and one-half hours, but this was often extended to four or eight hours between airports. The number of flights for all these ships totalled 1,588, duration 3,167 hours, 107,180 miles and the number of passengers carried was 34,228.

War Activities

At the outbreak of the war, the available commercial airships were taken over by the German army and operated for military and training purposes. The German navy at that time possessed one army airship, the L-3. Several similar airships were built for the navy and engaged in an extensive observation service. They proved satisfactory, within their limitations, but the inefficiency of their radio equipment made communication difficult and messages were often delayed in transmission until they were no longer of value when delivered. In the latter half of 1915, larger airships were available and the radio had been much improved. Bombs and machine guns had been added, making the airships more effective.

The personnel difficulty, however, continued to detract from the efficiency of the airship service. In the first place, the demands of other special services, such as airplanes and submarines, did not permit of as careful selection as desired, and the state of war necessitated a short, and more or less superficial, training. The new airship commanders were obliged to devote their time to the technical details of airships and neglected the military aspect of the situation, including the strict execution of orders. Older men were regarded as lacking in adaptability, and consequently young men were chosen for the airship service. The latter lacked the proper sense of responsibility and were susceptible of being diverted from their missions by side issues.

There is a lesson for us in this situation: Train your personnel before war breaks out. To do this, we must have airships.

German airships of about 2,000,000 cubic feet gas capacity during the war attained altitudes of 20,000 feet with a crew of 20, fuel for a 10-hour trip and 4,400 pounds of bombs. The L-72, an airship of 2,500,000 cubic feet gas capacity, reached an altitude of 21,300 feet, but was shot down over land on its first raid.

The loss of 61 Zeppelin airships operated by the German navy during the Great War was due to the following causes, as nearly as can be compiled from available records:

Faulty operation	7
Accidents in the hangar	5
Enemy action	27
(Of which 14 were shot down over land)	
Dismantled as obsolete	4
Lightning	1
Deliberately destroyed by crews to prevent delivery to Allies	11
Delivered to Allies	6

In spite of the characteristic unfavorable weather conditions of the North Sea, and the other handicaps under which they labored, the Zeppelins assigned to the German navy claim to have fulfilled the demands upon them so well that it became practically impossible for British vessels to approach the German coast unseen. By their expeditions, numbering over 1,000, the airships earned the name of "The Eyes of the Fleet."

Loss of the ZR-2

The United States Navy has had three rigid airships built, i. e., ZR-1, ZR-2 and ZR-3, the first being the SHENANDOAH and the last the LOS ANGELES. The ZR-2 was built in England along Zeppelin lines and was the largest airship ever constructed, being of 2,720,000 cubic feet gas capacity, or about 120,000 cubic feet greater capacity than the LOS ANGELES. This ship was designed for high speed and high climb, its carrying capacity being about 60% of its lift, which is the highest percentage of any rigid airship so far built; in other words, its construction was the lightest. The first trial trip showed that the frame was too weak, necessitating various repairs and reinforcements.

There are three sets of forces to be resisted by the structure of a rigid airship, namely, aerostatic, aerodynamic and dynamic forces. The aerostatic forces act in vertical planes and have to do with the lift of the gas acting against the force of gravity. The aerodynamic forces are caused by the action of the propellers driving the ship through the air, creating collapsing forces at the bow of the ship and, since the engine cars are not in line with the center of resistance, there is generated a moment tending to make the airship nose up, which must be neutralized by an equal and opposite moment produced by the horizontal rudders. The most important case of the dynamic problem occurs when, with the airship going at full speed, the elevators and rudders are suddenly thrown over to their full extent.

The ZR-2 was undergoing its last trials and had completed its speed tests during a 24 hour flight, when the rudder tests were begun, making 3 successive turns, with the rudder hard over. During the third turn the frame of the airship gave way near its center of gravity and the airship plunged in flames into the Humber River. The girders of the airship during this maneuver were subjected to a tremendous stress at the point where the ship broke in two and, due to her light construction, the girders were unable to withstand the strain.

Loss of the Shenandoah

The designs of the SHENANDOAH were begun in 1919 and were approved by a technical committee composed of scientists and engineers of national reputation. In its design approximately 4% more of the total lift was assigned to the hull structure and fittings than in comparable foreign designs. The airship was built at the Naval Air Station, Lakehurst, and completed in 1923. Finally completed, the weight of the ship exceeded the designed weight by approximately 1%.

Prior to her last flight, the SHENANDOAH had cruised about 740 hours in the air, covering 25,835 miles over land and sea. These figures would have been considerably larger if sufficient helium to operate the ship at all times had been available.

It was found by the Court of Inquiry that the final destruction of the SHENANDOAH was due primarily to large, unbalanced, external, aerodynamic forces arising from high velocity air currents. She first rose to a height of 3,150 feet, was steadied at that level for 6 minutes, then rose again and more rapidly to 6,100 feet in 10 minutes, dropped to 3,000 feet in 3 minutes and finally rose again, sharply up by the nose, to probably 3,700 feet, as which point the ship broke. This last rise was accompanied by a movement of rotation of the whole ship in a horizontal plane and by violent rolling and pitching.

Deterioration of structural material was found not to be a direct or indirect cause of the loss of the ship. The first break in the main structure of the ship occurred abaft the point of suspension of the control car, which separated the ship in two parts. In less than a minute thereafter the control car broke loose from the forward section and dropped to the earth. About the same time the second break occurred in the after section of the ship, about 30 feet from the broken end.

Although the disaster to the SHENANDOAH indicates that a rigid airship can probably be destroyed through external aerodynamic force only, and that such forces can arise from air currents unaccompanied by visible signs recognizable by aerologists in the present state of knowledge, it was the opinion of the Court of Inquiry that such conditions and combinations of circumstances are unusual and such a conclusion does not therefore throw doubt upon the safety and utility of rigid airships to a materially greater degree than does the fact that other types of craft for navigation in the air or on the water are likewise subject to destruction through unusual danger which cannot be foreseen and provided against. This disaster, said the Court, is part of the price which must inevitably be paid in the development of any new and hazardous art.

Naval Utility

The fundamental naval policy of the United States is as follows: "The Navy of the United States should be maintained in sufficient strength to support its policy and its commerce and to guard its continental and overseas possessions." Rights and interests may be roughly outlined as our thousands of citizens sojourning in all parts of the world; our $8,000,000,000 yearly trade; 1,260 merchant vessels plying 70,000 miles of trade routes over all the world; the Panama Canal; the open door policy that protects our standard of living; and our outlying possessions. Should any of these rights and interests be attacked, the Navy, while having a defensive motive, would have to employ offensive operations to crush forces attempting to deny us such rights.

The mission of the Scouting Fleet, to which most of our rigids would be assigned, is to search for and locate the enemy, but the Scouting Fleet is in fact an auxiliary of the Battle Fleet and would probably never be widely separated from it. The Commander-in-Chief cannot afford to scatter his surface vessels while superiority of gun fire is still the determinant of sea power.

The rigid airship lends itself to the carrying out of the various naval missions, resulting from our offensive-defensive war plan. The high sustained speed of the airship brings our outlying possessions closer to us. It is valuable for the rapid searching and patrolling of our tremendous sea areas and coasts. It can relieve scout cruisers for necessary concentration. It can protect convoys. It can transport urgently needed material and personnel.

A rigid airship of 6,000,000 cubic feet capacity filled with helium will have an endurance of 7,000 nautical miles at a standard speed of 50 knots. During fourteen hours of daylight such a ship can scout a sea area of 85,000 square miles, according to Admiral Moffett. She can fly at the same speed from the Pacific Coast to the Hawaiian Islands with a military load of 43 tons, or at a 70 knot speed with a military load of 34 tons.

The ordinance of the proposed 6,000,000 cubic feet airship contemplated by the Navy consists of seven .50-caliber machine guns; thirteen .30-caliber single-mount machine guns; five .30-caliber double-mount machine guns and one 1-pound automatic cannon. For these guns 9,700 rounds of ammunition will ordinarily be carried. The guns are so situated that an enemy aircraft cannot approach from any direction or angle without permitting a concentration of fire. Should the gas cells be punctured by bullets, the crew can stop these holes before any appreciable loss of lifting gas develops. It has been calculated that the ship of which we are speaking can be pierced with 200 holes, 20 holes one inch in diameter in each of the 10 gas cells, and lose but 25 per cent of her gas volume in five hours, if left unrepaired, but all parts of the gas cells will be accessible for repairs during flight, and these holes can be easily stopped.

Commercial Aspects

It has been seen that the German navy during the Great War set considerable store of security in its airship service, but that full advantage of their expeditions was not realized owing in great part to the lack of suitable personnel and the inadequacy of their training. At present, Germany is restricted by allied decree to building airships not much greater than one-quarter the size of the LOS ANGELES and, as this size is insufficient for practical purposes, it is probable that no airships will be built in Germany until the restriction as to size is removed, but there is little doubt that, if that country became engaged in war, rigid airship construction on an unlimited scale for naval purposes would be resumed.

In the latter part of 1919 the Bodensee, a commercial airship of 800,000 cubic feet gas capacity, built after the war, made 103 commercial flights, including 80 trips on schedule, between Berlin and Friedrichshafen, covering a total of 32,300 miles in 533 hours, at an average speed of 62 miles per hour, carrying 2,380 passengers, 11,000 pounds of mail and 6,600 pounds of express. This ship was then delivered to Italy by decree of the allies.

The LOS ANGELES was completed by the Zeppelin Company in Germany in 1924, and represents the latest example in commercial rigid airships. As will be remembered, she was flown by the builders from Friedrichshafen to Lakehurst in October, 1924, covering 5,100 miles in 81 hours. On the voyage she crossed the Atlantic from a point near Bordeaux, France, to Boston, in 64 hours. I was on board during the trip and it was a very comfortable voyage. The ship does not roll at all and the tendency towards pitching while flying over land is largely controlled by the use of the horizontal rudders. This ship has a passenger cabin which will accommodate 30 passengers by day and 20 passengers by night. The berths are comfortable and I slept 9 hours the first night of the trip. There is a kitchen with an electric stove, hot water heater, etc., also wash rooms and toilets for passengers. Hot meals are served in the passenger cabin on tables placed in the compartments.

In February of last year, the LOS ANGELES made a voyage to Bermuda and back. The weather was cold and it was necessary to add an anti-freezing agent to the water which was carried as ballast. Following, as nearly as was known, the German practice in this respect, calcium chloride was used as the anti-freezing agent. Unfortunately, we did not know all the German practice, as it has since developed that, whenever they spilled calcium chloride solution on the duralumin framework, they immediately renewed such parts. The result of our action with incomplete knowledge was that the duralumin in the lower section of the LOS ANGELES became corroded by the calcium chloride. Renewal of certain parts and a general cleaning were given the ship and she continued to operate until June of last year. When the helium was transferred to the SHENANDOAH, further examination of the structure revealed general corrosion in the lower parts of the ship, necessitating extensive replacements. This has now been accomplished. During this repair period the gas cells were removed and overhauled and when the ship again begins its flights, the latter part of this month, we expect her to be in good general condition.

The LOS ANGELES is used as a training ship and will be employed in this service for some time after operations are resumed. It is intended by the Navy Department later to use her to try out the possibility of commercial airship operation in this country.

In the commercial aspect there are three essential questions which are common to any form of commercial undertaking:

(a) Is airship transport required?
(b) Is it possible?
(c) Can it be run at a profit?

The value of the airship depends upon its suitability for high speed, long distance transport. The traveler, for whom the voyage is not an object in itself, always desires the greatest possible speed. Speed in itself is not the most important thing to the traveler but only the saving of time or, what amounts to the same thing, the reduction of the time lost.

The industrial growth of the nation has been made possible by railroads and steamships. No other public utility touches the lives of the people so closely as do the railroads. Across the seas we have valuable possessions in Hawaii, the Phillippine Islands, Porto Rico, Virgin Islands, Canal Zone, etc.

Consider the Philippines alone, whose vast commercial possibilities have scarcely been touched, largely due to the lack of swift communications. It takes the best part of a month for the regular steamers to reach Manila from the Pacific Coast. Airships can cut this time to one week. The airship route to Manila would lead from the Pacific Coast via Honolulu and Guam, where intermediate stations would be required, consisting of mooring masts and equipment for refuelling and gassing.

From San Francisco to Honolulu is 2,300 sea miles; Honolulu to Guam, 3,300; Guam to Manila, 1,500 miles; total, 7,100 sea miles. At a ground speed of 60 knots, which was the speed of the LOS ANGELES crossing the Atlantic, the time of a continuous voyage from San Francisco to Manila would be five days and, allowing two days for intermediate stops and contingencies, would make the voyage one week's duration. The airship for this route would have to be large enough to cover the longest distance, 3,300 miles, economically; that is, a ship such as the British government is planning for the Australian route, which will carry two hundred passengers and ten tons of mail and express.

To operate a commercial line of airships with daily sailings each way across the Atlantic, assuming sixty hours as the length of the voyage, would require six airships in service and two more in reserve. The economic ground speed for commercial airships is mathematically calculated to be 53 knots, or about 62 miles per hour, and it is customary to allow for a 20 knot opposing wind in planning flights, so it appears that the best still air speed to drive a ship is 73 knots. This cruising speed will no doubt be achieved in large airships, as experience in operation and design is gained, and engines are improved. The British 5,000,000 cubic foot ships are designed for a full speed of 72 knots, as nearly as can be ascertained, and the 6,000,000 cubic foot ship contemplated by the Navy Department is designed for 70 knots. The economic or cruising speed in these cases would be about 50 knots.

Water Recovery

In operating an airship filled with hydrogen, the ship becomes lighter as gasoline is consumed, and equilibrium is maintained by releasing hydrogen. A helium filled airship likewise becomes lighter as fuel is consumed, but helium is scarce and means must be had to preserve it. The system of water recovery fitted to the engines of the LOS ANGELES furnishes this means. Each engine is fitted with a condenser into which the exhaust gases are discharged and cooled. If the cooling is brought to 125° F. the vapor begins to condense; at 85° F. an amount of water equal in weight to the gasoline consumed will be condensed, and at 60° F. it is possible to recover 127% of the weight of gasoline used. The temperature of the gases at the exhaust ports is in the neighborhood of 1,600° F. so the apparatus must be efficient to reduce the heat to the amounts just mentioned. Very good results have already been attained, and improvements in the condensers are being made. The condensed water is run into tanks in the ship, and it is seen that, if 100% is recovered, equilibrium of the airship will be maintained.

The water recovery apparatus, moreover, permits the voyage to be begun with considerably less weight of water ballast, and a corresponding increase in weight of fuel or cargo. It was formerly considered good practice to start with water ballast equal in weight to the lift of the largest gas cell, so that in case of the failure of a cell, ballast could be discharged and the ship remain afloat. This weight for the LOS ANGELES would be over 17,000 lbs., but with water recovery installed we have started with 4,000 lbs. of water ballast, thus permitting an increase of some 13,000 lbs. weight of fuel.

Helium

The properties of helium make it peculiarly suited for use in airships. Although it is true that it has less lift than hydrogen by a few per cent, even with gas of highest purity, still the other properties of the two gases are so diametrically opposite that helium is another way of spelling "safety" in airship operation. Among the most notable of these properties are the facts that helium will not burn, it will not support combustion, and it has a low rate of diffusion through fabric and gold-beaters' skin, such as airship cells are made of. Another important fact is that the impure helium may be removed from the airship and purified, which of course means that, with careful operation and a successful system of weight replacement for fuel consumed during flight, such as water recovery, the supply of helium need not be rapidly consumed even with constant operation of the airships. The one main objection to helium has always been the high cost of production. This is constantly being reduced and, at the present time, the actual cost of production has reached a reasonable figure and future perfections should soon reach a production cost which will make commercial operation of airships with helium a real possibility.

Airship Bases

There will be two general types of commercial operating bases; one where there are hangars and mooring masts and the other where there are mooring masts only. It is evident that any operating company must have a total of hangars and masts at its main stations equal to the number of ships in the line. There might be two types of masts at terminal stations, one for landing and embarking passengers and one for the ships to moor to during their ordinary sojourns in port. An incoming ship would land at the passenger mast, discharge its passengers and then move to a storage mast for cleaning, overhaul and refuelling. When necessary to overhaul an engine, its gondola would be lowered to the ground and another placed on the ship. During its stay in port the regular crew of the ship would be relieved by a shore party.

Airships and Airplanes

It is believed that no rivalry exists in the commercial field between airships and airplanes, but that each type has its definite function, the types are complementary, and should develop together, assisting each other. For distances under 1,000 miles over land, the airplane is probably the best type, while the airship may be expected to link countries together instead of cities. If an airship line is established across the Atlantic the traveler will demand faster transportation from the airship terminus to his final destination.

In the old days, when it took two or three days to go from Philadelphia to New York the traveler was not concerned whether it took him half an hour or three hours to reach his destination after arrival, but nowadays, when it takes but two hours between these cities, the traveler demands quicker internal transportation, and the answer has been subways and taxicabs. The traveler crossing the Atlantic in a week is content to go by rail from the seaport to his destination, but if he made the crossing in sixty hours he would demand faster speed in his final transportation, and the answer to this would be the airplane.

It should be pointed out that the termini of airship routes need not be on the seaboard, but may be located in any center of population whose traffic warrants a terminus. For instance, the mooring mast at Dearborn, Michigan, might be a profitable trans-Atlantic airship station, since it stands within seven hours, or less, by rail, from Chicago, Buffalo, Indianapolis, Toledo, Columbus and Cleveland, and its location would considerably shorten the trans-Atlantic passage for people living in those cities, especially if airplane feeder lines were established.

Airship Construction

From the point of view of design, the structure of a rigid airship is a complicated problem, since the calculations cannot be made by the graphical methods employed on girder work. From a manufacturing point of view, however, the construction of an airship is quite a simple matter. The hull is composed of a large number of members, but all of a comparatively small number of types. In the LOS ANGELES there are 2,400 girders, but only 34 types. A girder is built of three rolled channels, connected together by stamped lattices. There are 459,000 lattices in the LOS ANGELES, but only fourteen types of lattices, The whole structure of a modern airship is a series of simple structures many times repeated.

The principal metal used in the hull structure of a 6,000,000 cubic foot airship would be duralimin, and in using this metal the builders will apply the lessons learned by experiences during the past several years and be able to work the material to better advantage. As airships become larger they can even afford to make certain highly stressed parts out of steel and it is probable that, with increased size of airships, steel will be used in increasing amounts.

The largest portion of the capital of a construction works will go into the hangar. It would therefore be necessary to organize the works so as to speed up the erection of the ships. In Germany, during the war, airships were built in as short a time as six weeks. The hangar would probably be constructed with doors at one end only. In the closed end would be placed the adjustable jig on which the main frames or rings, are erected. The rings would be constructed in their order, starting at the stern, which would be toward the open end of the hangar. As the rings were constructed on the jig they would be erected in place and joined by the longitudinal girders. The tail structures would be erected and the outer cover fitted in place as the hull took form. The engine units would be made detachable and would be placed in position when their points of attachment in the hull were completed. Thus as soon as the forward part of the cover had been completed the ship would be inflated, raised out of its cradles and removed from the hangar, when the erection of another ship could be begun. The girder shop in the meanwhile would have manufactured a sufficient number of girders so that the erection of the next ship could proceed at once. The engine shop, fabric shop, gas plant, etc., could be so regulated as to keep pace with the work in the erection shed. The engine units would be built separate from the hull, similar and interchangeable, which would tend toward cheapness in construction. The cost of the gas cells will be considerably lowered as soon as a substitute for the gold beater skin lining has been perfected. The total area of fabric for the gas cells of a 3,000,000 cubic foot ship is about ten acres. The entire cost of such a ship in quantity production in England has been estimated at about $1,000,000.

Some comparative figures in the operation of steamships and airships may be cited: A typical ocean greyhound displaces 53,000 tons and carries 3,230 passengers, the displacement per passenger being 16.4 tons. The displacement of a 5,000,000 cubic foot airship is 150 tons and it is designed to carry 200 passengers, the displacement per passenger being 0.75 tons. The weight of fuel consumed per passenger per mile for the steamship is 1.21 pounds and for the airship it is .09 pounds.

It is not too much to predict, in view of these figures, that airships will eventually be not only the fastest long distance carriers, but also that they will be the cheapest. If that is so, practically all intercontinental passenger traffic which demands speed will be carried by airships. As the LEVIATHAN is now mistress of the sea, so will the giant airship become mistress of the air.

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*Acknowledgment is made to Major G. H. Scott, C.B.E., and to Mr. W. Bleistein for data used in this paper.

The Air Mail

By HON. CHASE C. GOVE

Deputy 2nd Assistant Postmaster General, U. S. A.

THE United States Post Office Department is one of the greatest business institutions in the world by reason of the enormous volume of business it handles, and because it not only serves the great commercial cities of the country, but also the isolated villages in the most desolate parts of the United States and Alaska. It also serves every post office of its insular possessions and exchanges mail and conducts business with every country in the world.

A little more than a hundred and fifty years ago, just prior to the Revolutionary War, the first post routes were started. The mails were carried between the more important centers in the several colonies by runners, or by messengers on horseback. Later, where conditions permitted, the mails were carried by stage-coaches. When the postal system started postage was charged by the sheet and no envelopes were used. The rates were ten cents for one sheet, or twenty cents for two sheets for every fifty miles. Therefore, it cost twenty cents to send a letter of one sheet from Philadelphia to New York, or at the rate of twenty cents a sheet for whatever was sent. Today a two-cent stamp will carry a letter to Point Barrow, the most northern post office in Alaska, or to Cape Horn, the most southern post office in South America.

For many years there was little or no improvement in the mode of transportation of the mail. Less than one hundred years ago there was no such thing as a systematic foreign mail service. Letters were sent by courtesy whenever and however possible. To-day a five-cent stamp will take your letter to the remotest post office on the face of the globe.

Aeroplane Mail Transportation

The first really successful air flights in this country were made in 1908 when the Wright Brothers demonstrated their plane to the War Department at Fort Meyer Field near Washington. From that time on the development of airplanes of various types has been too rapid for accurate recording.

The first aerial dispatch of U. S. Mail occurred in September, 1911.

On the occasion of an Air Meet which opened at Garden City, Long Island, New York, September 25, 1911, Earle Ovington, one of the earliest and best known exhibition flyers in America, was appointed to carry the first mail which was ever carried by airplane.

Postmaster General Hitchcock in his annual report in December, 1911, made reference to this first flight, and stated—"the progress being made in the science of aviation encourages the hope that ultimately the regular conveyance of mail by this means may be practicable."

Recognizing the fact that a portion of the mails always have gone and always will go by the fastest means of transportation, a request was made of Congress in 1912 for an appropriation of $50,000 with which to establish an Air Mail Service, but this request was not granted. The Act of March 3, 1917, made appropriations for the Postal Service authorizing the Postmaster General to expend not exceeding $100,000 for the purchase, operation and maintenance of airplanes for an experimental airplane mail service between such points as he might designate.

The first experimental Air Mail route was inaugurated on May 15, 1918, between Washington, Philadelphia and New York, a distance of approximately 200 miles. The line was operated by Army flyers until August 10, 1918, when the Post Office Department reached the conclusion that a civil service could be best operated by civilian personnel. Accordingly, on that date, the world's first legitimate non-military air transport enterprise came into being. The Department soon learned that short flights in the Air Mail were of little or no advantage. It was apparent that when an hour or more was consumed in getting to and from each terminal flying field very little, if any, time was saved by airplane. It became evident, therefore, that the great speed of the airplane could best be utilized over long distances and between large commercial centers.

On May 15, 1919, the first flight was made on the Chicago-Cleveland route. On January 1, 1919, service was inaugurated between New York and Cleveland. On January 10, 1920, the first Air Mail was flown from Chicago to Omaha, and after May 15 daily service was maintained. In 1920 a route was operated for a short time between the Twin Cities (St. Paul and Minneapolis) and St. Louis via Chicago. The service was of little advantage and was discontinued June 30, 1921.

In those days Pilots were compelled to fly with the aid of very crude maps over what might be termed uncharted courses.

The Fall of 1920 (September 8) saw in operation the 2,665-mile transcontinental route. In the same year contract routes were established between Seattle and Victoria, (84 miles) to expedite the receipt and dispatch of foreign mail with arriving and departing steamers, and between Key West and Havana (90 miles). The New York-Washington route was discontinued May 31, 1921, and the company operating the Key West-Havana route discontinued operations. In 1922 a third contract route was started between New Orleans and Pilottown, Louisiana, to expedite the receipt and dispatch of foreign mail with arriving and departing steamers from that port.

From 1920 to June 30, 1924, the Department operated the transcontinental service as a relay service, i.e., mail was flown out of New York for Cleveland and points to be connected by rail. Another plane would take mail from Cleveland and arriving trains for Chicago and points beyond. This relay process was continued across the country in each direction. No particular mail was carried the entire distance by air though millions of letters prepaid at the ordinary 2-cent letter rate were advanced from 12 to 24 hours in delivery at destination.

Night Flying

On April 11, 1921, Colonel Paul Henderson became Second Assistant Postmaster General. His interest in the Air Mail was primarily as a transportation enterprise, not as an aviation laboratory. As an experiment it had fully justified its existence. It had pointed the way to the practical manner in which aviation could be developed commercially. As a laboratory only, it could no longer be reasonably maintained. By the Fall of 1922 investigations into the feasibility of night flying were so far advanced as to justify a practical demonstration. Postmaster General New authorized a test and on August 21, 22 and 23, 1923, through transcontinental flights were made from coast to coast leaving New York and San Francisco in the morning, flying in the night over a poorly lighted course between Chicago and Cheyenne, and arriving at the opposite terminals in the late afternoon of the second day. I had the pleasure of being in Omaha the night of the first flight and at about 11 P. M. a group of us at the Air Mail Field were perusing the newspapers published that morning in New York and San Francisco.

These trial flights were entirely successful, and on July 1, 1924, the first through transcontinental Air Mail schedule was put in operation, leaving New York and San Francisco about 9:00 A. M. and arriving at the opposite terminals about 5:00 P. M. the following day. On that date the Department discontinued carrying other than specially paid Air Mail. The rate of postage was fixed at 8 cents per ounce or fraction thereof for each zone. The route was divided into three zones; viz., New York to Chicago, Chicago to Cheyenne, Cheyenne to San Francisco, making the rate from points east of Chicago to points west of Cheyenne 24 cents an ounce. Only mail matter prepaid at the first-class rate of postage was carried.

On July 1, 1925, an additional schedule was placed in operation over a portion of the transcontinental route providing for overnight service five days each week between New York and Chicago. The mail for this overnight route closes at the General Post Office, New York City, at 8:00 P. M., is trained to the Air Mail Field near New Brunswick, New Jersey, and planes depart for Chicago at 9:40 P. M. with a scheduled arrival of 5:45 A. M. Eastbound the mail closes at the Chicago Post Office at 6:00 P. M. The planes depart from the Maywood Field at 7:30 P. M. and are due at Hadley Field, New Brunswick, at 4:45 A. M. Mail is trained to the General Post Office in New York, arriving there at 6:15 A. M., in time for first-carrier delivery. The postage rate for this service is 10 cents an ounce.

The revenue derived from the excess postage charged for Air Mail for the fiscal year 1925 was slightly in excess of $600,000. The excess postage on both routes is now running at the rate of approximately $75,000 a month or $900,000 per annum. The business is gradually increasing and it is estimated that the income for the present fiscal year will be in the neighborhood of $1,000,000.

Lighting of Airways

In order to maintain the transcontinental schedule in the winter time it was found necessary to extend the lighted airways from Chicago to Cleveland and from Cheyenne to Rock Springs, Wyoming. To place the overnight service in operation between New York and Chicago it was necessary to extend the lighted airway from Cleveland to New York over the Allegheny Mountains. The lighted course has also been extended from Rock Springs, Wyoming, to Salt Lake City, Utah, completing the lighted airway from New York to Salt Lake City, a distance of 2,041 miles, at a cost of $550,000 or $270 per mile. The annual expenditure for maintenance of this lighted airway is $300,000 or $147 per mile, divided as follows—wages 50%, rentals 20%, telephones 15%, repairs and replacements 10%, and fuel 5%. The lighting equipment is composed of four classes: beacon lights, flood lights, routing beacons and boundary lights. The use of the beacon light has a two-fold purpose; first, to guide the pilot along the route, and second to show him the location of regular or emergency landing fields. The beacon lights are placed on 53-foot towers. A revolving projector type of beacon which has a narrow beam of light is used. The drum revolves six times a minute, giving a flash every ten seconds.

The flood lights are used at regular terminal fields to give the pilot as nearly as possible a daytime perspective of the field when landing is made. In addition to the large field flood light, all buildings and obstacles are floodlighted by smaller lamps.

The routing beacons are distinctive; the electric rotates six times a minute, the gas beacons flash sixty times a minute, and they assist in keeping the pilot on his course.

The boundaries of all regular and emergency fields are outlined with electric lights (white) placed from 150 to 300 feet apart. The lighting unit consists of a vapor-proof fitting mounted on a pipe standard, usually about two feet above the ground. At regular fields the current is supplied by underground cable. At emergency fields, units composed of three or four cell primary batteries are used. All obstacles are marked with similar units using a red globe.

Aeroelectric power plants have been installed; power is generated by a wind-driven propeller, making it unnecessary to employ caretakers at the emergency fields. A maintenance mechanic visits each field once a week to wind the clock and oil the mechanism.

All planes used in night flying are equipped as follows:

(a) Running or navigation lights similar to those used by ships at sea, a red light on the left wing, a green light on the right wing, and a white light on the tail.

(b) Landing lights are projectors of the automobile type but of much higher power. One is mounted on the left wing tip and one on the right, on the upper side of the lower panel. Each light has a beam candle power of approximately 150,000.

(c) The instruments in the cockpit are painted with luminous paint and in addition small electric lights are provided to illuminate the instrument board and compass.

(d) For emergency use two parachute flares are installed in each plane. These may be released by the pilot if necessary to locate a field in case of a forced landing. The flare gives a light of about 30,000 candle power and burns four minutes. The flares have a radius of approximately one mile at 1000 feet altitude.

The transcontinental route is equipped with powerful radio transmitting and receiving sets at all regular or terminal fields except Des Moines, Iowa, and Rawlins, Wyoming.

At all stations on the lighted airway—New York to Salt Lake City—operators are on duty 24 hours daily. Between Salt Lake City and San Francisco 16-hour service is maintained at each station. (The Continental Code is used.)

The radio is used in transmitting weather reports, in reporting plane movements and in communication between fields; also between the office of the Second Assistant in Washington and the General Headquarters at Omaha.

Mileage Records

Each plane carries three log books, one for motor, one for plane, and one for propeller.

At the completion of each trip, entries are made in the log books showing the mileage flown, between what points, and the time consumed. Aften one hundred hours of service, motors are taken out of the ships for overhauling. Planes are taken into the Repair Depot at Maywood for reconditioning after 750 hours of service.

The Transcontinental Route planes are scheduled to fly from New York to San Francisco—2,665 miles—in 34½ hours. This time includes stops at 15 stations for service and exchange of mails. On the eastbound trip only 30 hours and 15 minutes are used. The prevailing winds are from the west.

Pilots and planes are changed six times on the route; at Cleveland, Chicago, Omaha, Cheyenne, Salt Lake City and Reno. The average flight for each pilot is 381 miles. The longest leg is between Omaha and Cheyenne, 476 miles, and the shortest, 184 miles, between Reno and San Francisco. This service is daily and the scheduled mileage for one year is 1,945,450 miles. During last fiscal year 2,501,555 miles were flown, of which 696,126 miles were night flights. In the same year 2,160,022 miles of mail flights were scheduled and 2,076,764 were flown, a percentage of 96 completed.

The scheduled mileage for one year for the overnight service between New York and Chicago is 358,644 miles. The westbound trip—726 miles—is scheduled to be made in 9 hours and 15 minutes. This time includes stops at 3 stations for service and the exchange of mails. Only 8 hours and 15 minutes is used on the eastbound trip. The prevailing winds are from the west. Planes and pilots are changed at Cleveland.

(Since July 1, 1923, the Air Mail Service has flown (approximately) 7,900,000 miles, of which (about) 2,000,000 miles were flown at night. During that period 75 crashes occurred causing damage of any consequence to ships; 21 were complete wash-outs, and 54 involved damage of varying degrees. In other words—our pilots flew more than 100,000 miles, or 4 times around the globe, for each wrecked ship, and more than 375,000 miles for each plane completely wrecked. Out of 44 pilots 9 did not have a single crack-up; 4 had 4 crashes each. One of these 4 pilots completely washed out 3 ships without serious injury to himself, and the fact that he is alive today is somewhat of a miracle. One of our very best pilots had an unusual streak of bad luck, and had 6 crack-ups during this period, two of which were complete wash-outs. During this same period 8 pilots lost their lives. This represents the loss of a pilot for approximately each million miles flown.)

Contract Air Mail Service

On February 2, 1925, new legislation was enacted which gave the Postmaster General authority to contract with any individual, firm or corporation for the transportation of mail by aircraft between such points as he may designate, at a rate not to exceed 4/5 of the revenue derived from such air mail. Under this legislation the Department has advertised for a number of routes:

(1) Boston via Hartford to New York.
(2) Chicago via Peoria and Springfield to St. Louis.
(3) Chicago via Moline, St. Joseph, Kansas City, Wichita and Oklahoma City to Dallas—Fort Worth.
(4) Salt Lake City to Los Angeles.
(5) Elko to Pasco.
(6) Detroit to Cleveland.

(7) Detroit to Chicago.
(8) Seattle via Portland, Medford, Sacramento, San Francisco, Fresno and Bakersfield to Los Angeles.
(9) Chicago via Milwaukee and LaCrosse to the Twin Cities.
(10) Atlanta via Jacksonville and Tampa to Miami.
(11) Cleveland to Pittsburgh.
(12) Cheyenne via Denver and Colorado Springs to Pueblo.
Chicago via St. Louis, Memphis and Jackson to New Orleans. (Night route—no bids received.)
Chicago via Indianapolis, Louisville and Nashville to Birmingham. (Atlanta.)

Contracts have been awarded for the following routes:

(1) Boston to New York (Commence on or about May 1).
(2) Chicago to St. Louis (Commence April 15).
(3) Chicago to Dallas—Ft. Worth (Commence May 12).
(4) Salt Lake City to Los Angeles (Commence April 17).
(5) Elko to Pasco (Commence April 6).
(6) Detroit to Cleveland } Commenced on Feb. 15.
(7) Detroit to Chicago }
(8) Seattle to Los Angeles (Commence on or about May 1).
(9) Chicago to Minneapolis & St. Paul (Commence on or about May 1).
(10) Atlanta to Miami (Commence April 1 on that part from Jacksonville south with extension to Atlanta on June 1).
(11) Cleveland to Pittsburgh (Commence on or about May 15).
(12) Cheyenne to Pueblo (Commence on or about May 1).

Bids have been received but contract has not yet been awarded on the route between Chicago and Atlanta. Several other routes are under consideration and just as quickly as data is assembled and the suggested routes are fully studied to determine their practicability, additional advertisements will be issued. Each of the contract routes with terminals at New York, Chicago, Cheyenne, Salt Lake City and Elko will connect either with the overnight schedule between New York and Chicago or with the transcontinental schedule of the government-operated service. The postage rate on these contract routes is ten cents an ounce or fraction thereof for all mail carried, which must also be prepaid at the first-class letter rate. Where a letter passes from one contract route to a zone of the government-operated service and on to a second contract route, the postage rate will be ten cents an ounce or fraction thereof for each contract route and five cents for each zone of the government-operated service over which the letter travels. In other words—the postage rate from Boston to Chicago will be fifteen cents; or from Boston to St. Louis, Dallas or Minneapolis will be twenty-five cents. From Boston to Los Angeles the rate will be thirty-five cents.

The combined distance covered by the twelve contract routes which are already in operation or will be not later than June 1, is 4,300 miles, 2,799,574 miles of scheduled mail flights annually, linking, in conjunction with the government-operated transcontinental route of 2,665 miles, with 726 miles of service operated twice daily, a majority of the big cities and commercial centers of the United States. Additional routes which will be inaugurated in due course, closing up the gaps and including other large commercial centers, will complete a net-work of air lines in the United States equal, I believe, to all of the lines in operation in Europe today.

Future Development

It is my opinion that within a period of from three to five years commercial planes will be flying at night on regular schedule between all of the large business centers where the distance cannot be covered over night by train. This flying will be done, for the most part, without the aid of a lighted airway. It will be brought about by the use of improved types of engines, planes and navigating instruments, all of which will enable a pilot to fly a given course with a high degree of safety without the aid of a lighted airway or other landmarks.

The use of twin or triple engined ships will no doubt remove many of the hazards which now exist due to forced landings, and will make it possible to use ships of a greater cruising radius and with sufficient weight carrying capacity to transport several thousand pounds of pay load; thus greatly reducing the cost of this means of transportation. Within a few years there will be planes operating in this manner with sufficient cabin space to enable a clerk to accompany the mails and make a limited distribution of them en route, similar to that performed by the route agents on the railroads some 60 or 70 years ago.

The problems before us are varied and numerous; they are novel, complex and, so difficult as to exhaust the ingenuity of the most resourceful engineers and inventors of the day, but great progress has been made and the development has just begun.

English Air Transport

An Address by

MAJOR GENERAL SIR SEFTON BRANCKER,

Director of Civil Aviation in the British Air Ministry

PRESIDENT CLAYTON W. PIKE:

We are honored tonight by the presence of a most distinguished foreign aviator—if indeed I ought still to call England foreign—and one of the most important figures in aerial transportation today; at the beginning of the World War he was in command of Aviation under Lord Kitchener, and then in command of the Flying Corps under Lord Allenby, at the taking of Jerusalem; later the Director of Military Aeronautics of the British Air Ministry, and since 1922 at the head of Civil Aviation in Great Britain under the Air Ministry—the president of the oldest and most distinguished Aeronautical Society, the Royal Aeronautical Society of Great Britain. I present Major General Sir Sefton Brancker.

SIR SEFTON BRANCKER:

I am very much honored at being asked to speak tonight on this very important occasion. I should like to say at once, regarding the flattering remarks your Chairman has made, that he omitted one important item. That is, in June, 1918, I was fortunate enough to be sent to this country at the head of an Aviation Mission. I have been here twice since and I propose to keep on coming here so long as you can tolerate me.

I listened with very great interest to the proceedings this afternoon when Mr. Keys, Colonel Henderson, Mr. Stout and Captain Steele read their papers,* and I think perhaps this evening I had better tell you what we have been trying to do in England regarding air transport, with special reference to the statements made this afternoon. In England we have been struggling with air transport now for just seven and a half years, because we started the moment the war was over; and incidentally we have suffered from various handicaps. We have had a good many international troubles, not being allowed to fly across Germany, for instance. We have had a series of varying policies. I think we have had five or six changes of policy, in the administration of our air transport by the Government, in those seven years and, we have also suffered —I think you have, too—from a very bad financial slump in business circles.

Those seven and a half years of flying across the Channel I have always looked upon as a full-scale experiment; the distances covered have not been sufficiently long to treat our efforts as really serious air transportation. But we have learned a good many valuable lessons, and those lessons we are about to apply to the air communications of the Empire, which are our most interesting problems and involve great distances. I will start with a few figures. I do not like figures myself; they can be twisted about to prove anything, but they are sometimes necessary. It may be a platitude to say that any form of transportation, to be any good, must be safe, it must be reliable, and it must be more or less economical.

To take safety first: Since 1919 we have flown over 5,000,000 miles on the regular subsidized air routes which are under the general supervision of Government. I think that is the equivalent of 200 times around the equator. During that time we have carried over 70,000 passengers and about 2,000 tons of freight, and during the whole of that time we have only had four accidents which involved the death of passengers, and I think the total cargoes lost were three. That is not such a bad record and it goes to prove that air transport is very, very safe. There are a great many people who do not believe it is safe today, although these figures are there to prove it, and I am afraid, to some extent, even the aviation people themselves are rather apt to encourage the general public to think that aviation is dangerous.

I remember an amusing case which occurred at a place called Amman. It was on the way across from Palestine to Mesopotamia. A distinguished Government official from the Colonial office was told he had to travel by air; it would save him about three weeks. He had never flown. He did not particularly want to fly. He arrived at the aerodrome with a great deal of baggage. He looked at the machine and his baggage being piled in. He turned to the pilot and said: "Are you responsible, or am I, or the officer commanding the station, to see that the machine is not overloaded? Who really is responsible?" The pilot said, "You had better go and ask the commanding officer." He repeated his question and the commanding officer replied, "That is a question which will have to be settled at the **inquest!**" That reduced that already nervous official to prostration and incidentally, he came back by boat.

Now, with regard to reliability, our statistics so far go to prove that in the European climate we can get about 96 per cent reliability in the summer weather but, in the winter weather, we go down to 87 per cent. Of course, that is not good enough for the business man or the mails. That we shall have to improve. To go further into figures, we find that, of these failures of 4 per cent in the summer and of 13 per cent in the winter, two-thirds are due to weather—that is, bad visibility—and one-third to mechanical defects, and the latter are practically always some trouble in the engine. Later I shall come to our efforts to improve this condition of affairs.

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*See Engineers and Engineering, May and June, and page 175 of this issue.

To come to the third platitude—that is, economy—it is rather difficult to work out exactly what air transport has cost us to operate, because we have had five or six changes of system. We are just getting down to continuity now and, so far as I can gather from the figures available, we have been flying at about $1.00 a ton mile at 90 miles an hour—somewhere about that figure covers all overhead charges, insurance and everything else. Mr. Keys today indicated that we have been paying out $2.00 for $1.00 returned and I think that is really about what has been done. We have had to subsidize these lines to keep them alive at all. We have now come to the point where three lines of improvement offer themselves, all of which we are pushing along steadily. First, we have to improve the ground organization, in order to increase our standard of reliability. Second—and this is very important and perhaps it is the key of the whole situation—we must design better aircraft and engines—machines that will be cheaper to maintain and more reliable and safer to operate. And, third, which is quite a separate item, we have to educate the public in order to increase the traffic. The volume of air traffic today is much smaller than it should be, considering what it has to offer.

Taking the ground organization first: Mr. Keys and Col. Henderson both talked this afternoon about the lighting of the airways and radio communication. After our experience we have come to the conclusion—and I think Col. Henderson agrees—that we must break away from guidance on the ground altogether. We must reduce the lights on the ground to the minimum. We must forget that there are such things as ground marks and physical features. We must navigate from field to field, and that navigation will be carried out by directional radio. We have got to the point now—and we have been flying for three years with wireless telephony—where every commercial aircraft transporting more than four passengers carries radio equipment; and the pilots today, although they pooh-poohed it three years ago, will not now willingly cross the Channel without it. This enables them to find out what the weather is in front of them and by means of it they can be given their exact position on the map. The system is being steadily improved and I hope that this improvement will bring about a very big increase in the measure of our reliability.

Col. Henderson mentioned the question of providing and maintaining fields; he said he considered the actual laying out of the routes, or air ways, a matter for the Federal Government, whilst the provision of the fields—the ports of call—was a matter for the municipalities. That is very much like the system on which we are working. The British Government considers itself responsible for providing the airports necessary for international air transport and beyond that we depend on the big cities to provide their own landing accommodation. The Government arranges for the lighting and general organization of international air routes.

Up to date our big cities have not responded, because there is very little incentive to fly in England, but we have an airport near London and another near the coast for customs purposes which are run by my department in the Air Ministry.

The next item I wish to mention is the improvement of air craft. First, as regards their cost of maintenance. I have been thoroughly into the figures of 1924; the 1925 figures were not available when I left England in the middle of January.

The actual operating costs of the standard aircraft on the cross-Channel routes, leaving out insurance, were as follows:

Engine maintenance	44 per cent.
Aircraft maintenance	20 per cent
Fuel and oil consumption	30 per cent
Sundries (pilots' flying pay, etc.)	6 per cent
	100 per cent

In order to go further into these engine troubles, which account for 44 per cent of the cost, I found out for what causes engines were taken out of aircraft for repair or overhaul; I discovered that 28 per cent of the causes were due to water trouble, 19 per cent to valve trouble and 10 per cent to oil circulation—a total of 57 per cent of the engine maintenance costs thus being due to water cooling valves, and oil.

We have the cure to the first item already at hand, in that water troubles can be eliminated by the use of air-cooled engines, which we are adopting generally and putting into service this summer. The elimination of valve trouble is largely a matter of improved design, and I understand that you have an engineer in this country who is going to get around it by operating his valves by hydraulics, and improved oil circulation is again largely a matter of detail in design, patience and expenditure of money. So you see that 44 per cent of our costs were due to the engine maintenance; and more than 50 per cent of that maintenance can be eliminated by a little progress and experience. That I give you as an indication of how cost of operation can be brought down in the future.

Next; we are definitely developing all-metal aircraft. I reckon that we are then going to save very considerably on that item of 20 per cent for aircraft maintenance, not only that, we are going to save in constructional weight and so add to our paying load.

Then there are various methods of increasing the paying load which we are applying, and which I think you are developing here also, such as variable pitch propellers, booster engines, etc.

The third item is the cost of fuel. I still have an open mind but I am not sure that in the next ten years you won't see a great proportion of commercial aircraft operated by heavy oil. We are pushing on toward the successful production of a heavy oil engine. I think you are doing likewise.

Another big item on which we shall save is the insurance costs. A very interesting fact was brought to my notice before I left England. The latest insurance rates offered were 17 per cent a year on aircraft with a single engine and only 7 per cent on aircraft equipped with three engines, which shows the trend of insurance companies' ideas as regards safety from damage.

Finally, the question of educating the public and so obtaining more traffic. I see that Philadelphia is really leading the way there, because, from what has been said, you are going about it in the right way; your programme at the Exhibition will do much towards making everybody understand what aviation means, take an interest in it and make use of it. In our country the public are extremely conservative; we have a large class of people in England who may be described as the terra firma type. I will give you an illustration of the attitude of some of the British public toward aviation. At an airdrome on the south coast, we held a light airplane competition and a lot of these small aircraft with small engines were flying about; a friend of mine was walking along the edge of the airdrome one morning and he saw an old lady looking over her garden wall, watching proceedings.

"Hello, mother" said my friend "are you enjoying yourself?"

"No," she replied, "I am not."

"And why not?"

"Well, it is like this. Ever since I was a little girl and a bumble bee got up my petticoats I 'ates them things that buzzes."

That I find is rather the public attitude; aviation is looked upon as noisy—and possibly rather painful if you come into touch with it. Yet in spite of this conservatism, traffic is steadily going up, and I will give you a few more figures.

The total number of passengers carried across the English Channel in 1922 were 12,200; in 1923, 15,500; 1924, 17,500; 1925 about 20,000. So, you see, there is a steadily increasing demand from the public. Let us take another set of figures which are promising,—we have our big traffic in August, the holiday season—in August, 1923 we carried 2,000; August 1924, 2,600; August 1925, 3,200. So the curve is going up steadily.

I dare say that you have often heard that the chief use of the British air lines is to convey Americans to Paris. Well, actually last summer I think the figures proved that 30 per cent of the passengers carried on British aircraft were Americans; so we do owe you a deep debt of gratitude for keeping our planes running! The percentage of Americans carried on French aircraft is probably higher because the French themselves cannot afford to travel much by air. The British naturally will travel British always, if they can, and the Germans, who travel a good deal, won't go French, so we get the best selection of traffic.

Up to date, European air mail traffic has not been very successful, chiefly because there are very few reliable air lines flying over long distances and it is only long distances which can obtain the patronage of the public as regards mail. The best example of a successful mail service is the French line from Toulouse down the East coast of Spain to Casablanca which offers a very considerable saving in time. The number of letters which have been carried in the last four years is interesting: 1½ million letters four years ago; the next year, 3 million; the next year 4 million; and, in 1925, 5 million. There, you see the public making steadily increased use of the facilities offered.

In Europe, up to date, freight carrying has been of rather secondary importance but the future is extremely promising. The volume of freight carried between London and Paris and between London and Cologne is going up very steadily. Among the items carried are ladies dresses and hats, worth more than their weight in gold and going out of fashion in a few days; samples of wine; films; fruit; and then we have also had large consignments of boots, motorcycles and tobacco—and of all duitiable goods. Last summer the customs office was collecting as much as £7,000 a week in customs duties on silk goods at the air port of London alone.

Then another item, which may well affect you, is the transport of bullion. Nearly all bullion travels by air, first, because interest is saved thereby, and, secondly, it is considered safer. The insurance companies charge a lower rate on these valuable cargoes despatched by air. There is less chance of pilferage and loss. During the last seven years on British lines we have lost only two or three cargoes.

Generally speaking there are two lessons we have learned. One is that you must fly over long distances for really good results in air transport. That is a fairly obvious fact, and has already been pointed out by your representative from the American Postoffice.

Secondly it is quite apparent that competition on air lines is not necessary at this stage of development. The new industry is too weak on its wings to face keen competition. We must trust the administration to fly efficiently and keep competition for the future. We in Europe have competition with our neighbors but I think we could get on just as well without it.

With improvements toward perfect reliability, more efficient aircraft and a greater volume of traffic, I cannot see why we should not reduce the operating costs to something like 50 to 60 cents per ton mile at 100 miles an hour in the near future and, if we do that, air transport will soon become a commercial proposition without any artificial support from the Government. We are doing one thing in England which is against all ideas of what ought to be done by Government; we are spending money in ordering experimental commercial aircraft; our reason is that we look upon the air transport organizations of today as being too weak and too poor to afford really sound, technical development in experimental aircraft; therefore, to some extent, the Government is taking on its shoulders the responsibility of developing commercial aircraft; I think so far that this policy has proved itself sound.

It is very interesting, coming here and hearing your ideas on air transport. First, in disagreement with most of the world, I find America extremely modest about aviation. My first experience was in 1918, when I came over here on a mission and arrived to find everyone damning the Liberty engine and saying it was no good. I made myself popular by explaining that the rapid development of the Liberty engine was the biggest feat in aeronautical engineering that had been accomplished during the whole of the War. It had been designed and produced in record time and, after one year of development, it was flying in the air satisfactorily; one of the results of my visit was that we managed to obtain five or six thousand of these engines for England.

Again, most Americans coming over to London tell me "America is doing nothing in air transport." I come here and find a service between New York and San Francisco, flying over two million miles a year—which I think is about what both Germany and France are doing—and 700,000 miles at night! There is no regular night service actually operating in Europe today. There have been a few efforts but they have been irregular. Yours is the only service in the world flying over 2600 miles by day and night continuously in about 30 hours and I can honestly say that it is a magnificent performance. Americans coming over to Europe do not seem to realize it.

You have also, I am glad to see, pushed what is really a British industry in this country—sky writing. Some of your big business men have used that form of advertisement with great efficiency and courage, and gained good results, whereas in Europe it has fallen rather flat.

It is very interesting to see that the United States and England have done almost everything in opposite directions since the end of the War! The British Government have tried to encourage private enterprise by means of subsidies. Subsidies are very unpleasant things and they always come back and hit you, like a boomerang, at some tender portion of your anatomy! But they are necessary evils in Europe as a means of forcing on an industry of such vital importance to Imperial communication. You, on the other hand, have refused to subsidize and have run State services. Then we find in Europe that passengers are most generally carried by air. Here you carry mails but no passengers. In Europe we have a very complete set of aerial laws, laws made before even machines were available to fly. Here you are flying a great deal but you are completely lawless, so far as I can make out. We pride ourselves on our organized air routes, regular air services. At the same time we have very little in the way of private flying. You have a great deal of private flying—a great deal more than anyone realizes. I have learned a lot about it in the last three weeks; a very large amount of flying is going on that is not recorded by anyone. Then you are doing night flying in your country and, in Europe, we have limited ourselves almost entirely to day flying. I met another funny little item of difference when I flew the other day from Detroit to Cleveland and was made to put on a parachute; I did not want to use it but I find that here everybody has to wear a parachute; while we, on the other hand, have no parachutes but insist on radio being carried by all big commercial craft.

To say a little about laws: Mr. Stout, this afternoon, maintained that the insurance companies should be depended on to see to it that air transport was safely and properly operated. Well, I agree—and that has always been my theory in England—but, unfortunately, in England, the Transport Companies are too poor to stand the charges which would be made by the insurance companies if they had that responsibility; actually, both sides rather welcome the Government's taking the responsibility of licensing inspection for nominal fees in order to ease the financial situation. I think we have rather "over-regulated" because our regulations were made before we had full experience; personally, I am very much in favor of relaxing a certain number of our regulations. Unfortunately however, I am rather an exception and I find that most people want to cling to the existing regulations in spite of what the Press has said to the contrary. Generally speaking, the principle I would like to go on is that the Government should be responsible to the public for their safety on any regular air service.

flying to a time table and recognized by Government, but that the private individual should be allowed to break his neck as much as he likes.

This afternoon, I think it was Mr. Keys—I am not sure—perhaps it was Mr. Stout, raised the question of the military value of air transport and of air-ways. Of course, air-ways have a very considerable military value—probably more to the British Empire than anyone else. You can readily imagine that well-organized air-way between Egypt, India, Singapore, and Australia, is going to be of great strategic importance to us. Generally speaking, in the administration of air transport I would recommend that military aviation should be forgotten as much as possible. Air transport should grow up naturally and without any military ideas or military restrictions; when it grows up and when it is a commercial success, automatically it will provide a great military reserve without any trouble at all.

I think I must just mention our first step in real long distance work; next December we are going to put into operation a line from Cairo through Bagdad to Karachi in India. This service presents a problem somewhat analogous to that route of yours between New York and San Francisco. It is about the same distance and it covers a great variety of country but it has the disadvantage that about two-thirds of it lies over either a waterless desert or the completely wild and undeveloped coast of the Persian gulf. We are going to operate this route with three-engine machines. Single engine air craft would be too prone to forced landings; in this wild country, forced landings would involve heavy expense in salvage and some danger to crew and passengers.

Captain Steele this afternoon had a word about airships, and, personally, I agree pretty well with everything he said. I think airships have a tremendous commercial future but I do not think they are rivals of the airplane; we in England are going along with both of them. We know a good deal about the operation of airplanes but very little of airships because they cost a great deal more in money and time to develop. Our policy today is to start an experimental service operated by the Government from London to Karachi in India. If this experiment is a success we hope to get commercial enterprise to take the ships over and establish a service to Australia with one or more stops en route. We are building two new ships. They will have about 3,500 horse power. Their top speed will be 78 miles an hour; cruising speed, 65 miles an hour; disposable load 85 tons available for crew, cargo and fuel. Captain Steele indicated that they could carry 200 passengers. On paper, they can; but we are being conservative and we are fitting them to carry 100 only. The passengers are going to be comfortable; they are going to have a lounge and sleeping accommodations which will be at least as good as the Pullman accommodation of a train. They are going to have a dining room in which fifty persons can dine at a time and a small smoking room. In addition to the 100 passengers, a considerable tonnage of mail will be carried.

We are going to use hydrogen; we cannot get helium and, as we cannot get it, we say we like hydrogen best! The great advantage of hydrogen is that it gives a much better paying load. With helium you lose about one-half the paying load that you would carry with hydrogen.

The two ships are different in many respects. The Government ship is going to be built of stainless steel, which is quite an innovation, and the private built ship of duralumin. The Government ship will have heavy oil engines with a water recovery system. In the privately built ship, engines driven by kerosene and hydrogen, will be fitted, which is another innovation. Our contract with the airship manufacturers stipulates that the airship shall fly from London to Karachi in one hundred flying hours. These big ships naturally take a good deal of time to develop. We hope they will be flying at the end of 1927, in which event we can carry out this experimental service in 1928; by that time you may be flying from New York to London!

Mr. Keys excused us for using subsidies this afternoon on the plea that it was necessary for us to create air transport in order to establish it on our Imperial communications; in that I entirely agree with him. Our air transport within Europe is of very little good to us but when we extend outside Europe, it is going to be of enormous value to us in keeping the Empire together. With an airship service flying at 60 miles an hour we shall bring Australia to Somaliland; India, to Egypt; and South Africa, to French Morocco; Canada will come two-thirds of the way across the Atlantic. That means something enormous to us as an Empire. One of our difficulties at present is quick and personal communication. We have discussed the question of increasing the speed of our steamship services but that has proved to be quite impossible without heavy subsidies; so we are going out for aviation as an aid to these Imperial communications.

America has several advantages over us. You have great distances over your own soil and great industrial centers scattered over these great distances. You have a better climate; it offers much better visibility and it is more stable and reliable. You have a very wealthy and enterprising people. I reckon that in the next five years you ought to make this new industry pay. I often say that I have seen all my dreams come true in military aviation. I hope to see all my dreams regarding aerial transport come true;

and I think they should come true here before any other country in the world.

There is one other point I should like to make, which does not affect you because you are away from all these European troubles. There is a spirit of camaraderie in aviation which is stronger and better than any that exists in any other walk of life I know of. I happen to have been the British representative on the International Commission on Air Navigation for the last three years. We have about fifteen members and it has been a most happy family; interests have clashed but everyone has sunk his own interests in order to get mutual agreement and cooperation. So I think air transport is going to do something toward solving our European troubles and getting the various nations of Europe closer together than ever before. I thank you very heartily indeed for having listened to me with such patience and I thank The Engineers Club of Philadelphia most sincerely for its hospitality.

(*Will be continued in August issue*)

Conservation of Power in Industrial Plants

Discussed at a Meeting of

The Engineers Club of Philadelphia

February 16, 1926

Presiding Officer—Afternoon Session

Dr. Robert A. Fernald, Director, Mechanical Engineering Department, University of Pennsylvania

(*Continued from page 164 of the June issue*)

High Pressure Prime Movers in Industrial Plants*

CORRECTIONS

On page 153, below Figure 1, under heading "A," third line, the word "pressure" should read "superheat."

On page 155, 18th line of first paragraph, after the word "assumed" add "the year containing 6,500 hours."

On page 156,

Table II. Add under "Energy Production" Engine Room Fixed Charges on Investment "$34,250," and correct figures opposite "Cost of Steam per 1,000 lbs." to read "$.433, $.437, $.478," and opposite "Cost of Electric Energy per K.W. hour" to read, ".39c, .37c, .38c."

Table IIa. Opposite "Cost of Steam per 1,000 lbs." change to read, "$.70, $.75, $.88" and opposite "Cost of Electric Energy per K.W. hour" to read, ".83c, .82c, .87c."

Table III. Opposite "Cost per K.W. hour for the additional power" change to read, ".68c, .67c, .71c."

The Use of Exhaust Steam for Process Work in Textile Plants**

DISCUSSION

MR. BIGELOW (Specialty Manufacturing Corporation): We have used exhaust steam for process work but a difficulty in using the exhaust steam from the turbine is that demands for exhaust steam, or process steam, do not synchronize with the demands for power. I found in one case that either the relief valve opened, allowing steam to escape, or the make-up valve opened, admitting high pressure steam. A bleeding turbine worked very much more satisfactorily, as it would take care of this question of the two demands not synchronizing.

T. J. KENNY (Sheffler-Gross Company): The results of a test on steam economy in a dye house nearby might be useful as a check at this time.

This particular plant dyes khaki cloth. The steam pressure is 80 pounds and it had been their practice to dye at a boil, i. e., 212° F. The manufacturer of the dyestuffs had assured them that they would get equally good results by dyeing at a somewhat lower temperature—say at 208° F.

Of course, it was practically impossible for them to control this temperature manually; but by the use of an automatic temperature regulator, they were able to maintain this lower temperature, and the tests showed a steam saving of at least 25%. In addition they were able to obtain better shading and quicker matching of colors.

One way to account for this steam saving seems to be that at the higher temperature the dye liquor was unable to assimilate a large part of the heat that the steam could supply, and that a considerable amount of steam wasted through the liquor to the atmosphere.

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*See page 151, Engineers and Engineering, June, 1926.

**See page 160, Engineers and Engineering, June, 1926.

Heat Insulation in Industrial Plants

By L. B. McMILLAN,

Chief Engineer, Johns-Manville, Inc., New York

IS the engineer, or the executive in charge of an industrial plant, disposed to look upon heat insulation as an incidental, a detail, a matter of routine, or has he given due consideration to its far reaching influence and its relation to production, to economy and to productivity of labor?

Some Observed Conditions

Volumes have been written about radiation losses and it is common knowledge that by far the greater portions of these losses are preventable by the use of suitable insulation, yet consider the significance of the following observations made in a large manufacturing plant. An engineer or manufacturer might well consider whether these observations or others of similar import might be made in his plant.

1. A boiler house modern and well kept in every respect but lacking in steaming capacity for maximum production demands, when a portion of the boiler capacity was not available, due to necessary repairs.
2. A manufacturing building occupied by row after row of enormous kettles which constituted the principal steam demand.
3. In spite of open windows and cool outdoor temperature, the air was stifling hot and working conditions correspondingly unpleasant.
4. Not one of the kettles was insulated.
5. There were many other places in the plant where valuable heat was escaping but most of these others were where steam lines had once been efficiently insulated with, however, material not sufficiently rugged to withstand the conditions of wear and tear encountered in the average manufacturing plant.

The obvious conclusion from these observations was that enough of the "principal steam load" was radiation loss to make effective stoppage of this loss equivalent to putting one of the disabled boilers back on the line and helping to bring production up to the desired point. Improved working conditions and a large saving in fuel would also result. Thus, this example illustrates the influence of insulation on all three of the factors referred to in the opening paragraph.

Useful Curves

Engineers recognize the fact that to operate with bare steam pipes would be poor economy but the same attention has not been given, to other heated surfaces. Everyone realizes, nevertheless, that such surfaces without insulation are subject to considerable loss and, once the magnitude of these losses is visualized, it becomes immediately apparent that a substantial reduction would be highly desirable. The significance of heat losses expressed in B. T. U. is not as readily apparent as when the losses are expressed in the equivalent actual cost in dollars. In Figure 1, the equivalent losses in dollars per sq. ft. per year, 8,760 hours, have been shown for various values of heat per 1,000,000 B. T. U.

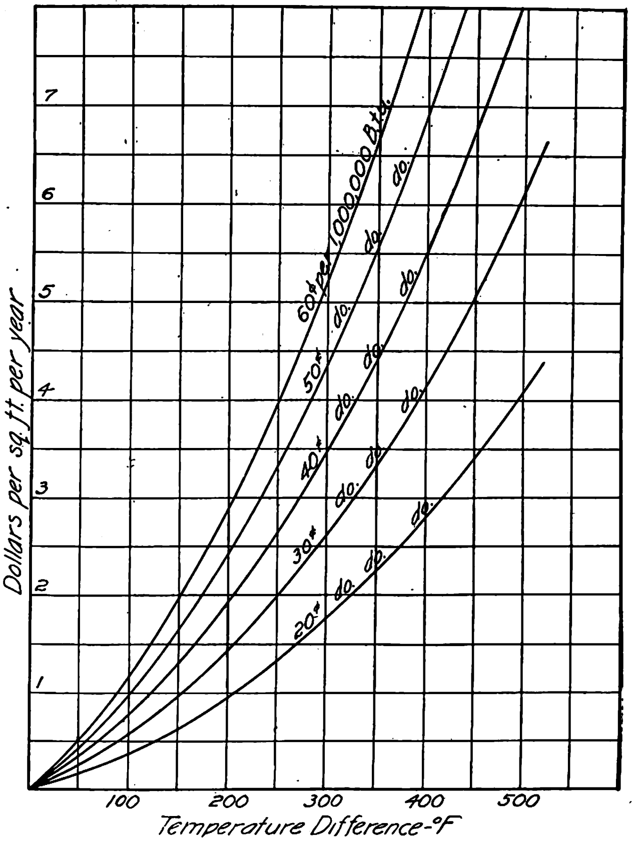

FIG. 1. COST OF HEAT LOSSES PER YEAR AT VARIOUS VALUES OF HEAT PER 1,000,000 B. T. U.

Such a chart is applicable to a wide range of fuels and conditions because, in a given case, the cost of heat per 1,000,000 B. T. U. is either known or is easily determined for fuel of a known cost and heat content and at a given efficiency. It will be noted that, as the temperature difference increases, the monetary losses mount very rapidly. Taking as a specific example a boiler drum operating 7,200 hours per year at a temperature 300° F. above that of the surrounding air, the loss per sq. ft. at 40c per 1,000,000 B. T. U. is $\$3.45 \times \frac{7200}{8760} = \$2.84$. Suitable insulation, saving above 90% of this loss, may be applied at a cost considerably less than half of one year's saving. This illustrates the desirability of insulating such surfaces as boiler heads, flanges and fittings, which frequently are left uninsulated even though adjacent piping is provided with effective insulation.

The large proportion of the loss from bare surface which may be saved by the use of suitable insulation is illustrated graphically in Fig. 2, the shaded portion representing the saving.

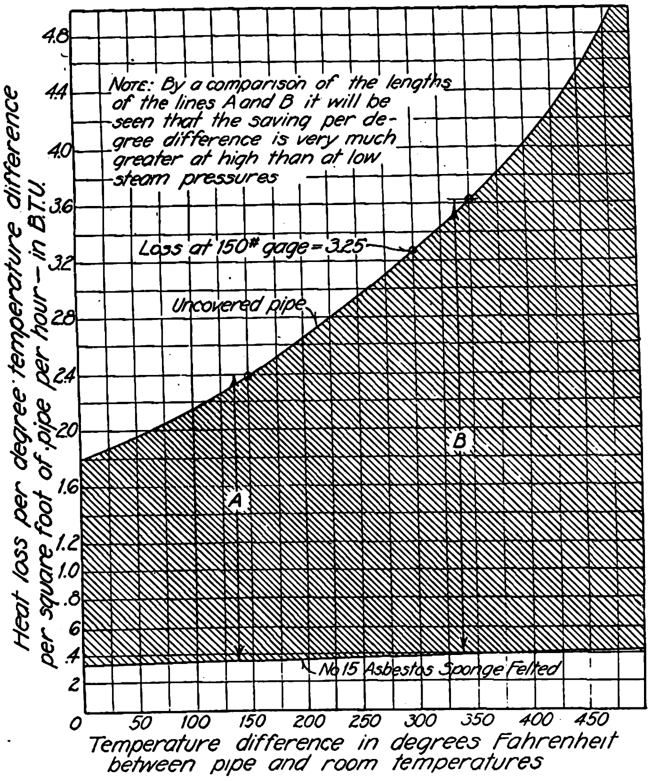

FIG. 2. LOSSES FROM BARE PIPE AND SAVINGS EFFECTED BY INSULATION*

Fig. 3 is another illustration of the same import and, if the extent of the shaded portion is any less striking, it is only because of the fact that the scale of the upper part of the chart had to be reduced to 1/20 that of the lower part in order to keep the diagram a reasonable size. Fig. 3 shows also losses through several different thicknesses of insulation proportioned to meet the requirements of various ranges of temperatures. A further difference between Figures 2 and 3 is that the former shows loss per degree temperature difference per hour, while Fig. 3 shows total losses per hour for surfaces at various temperatures and with air temperature of 70° F.

Effect of Circulating Air

The foregoing discussion refers particularly to losses under still air conditions. Many heated surfaces in industrial plants are exposed to circulating air. This is especially true of apparatus and pipe lines located out of doors but applies also to many indoor conditions. Heat losses from bare surfaces are greatly increased by air circulation. This is illustrated by the curves for various velocities shown in Fig. 4.

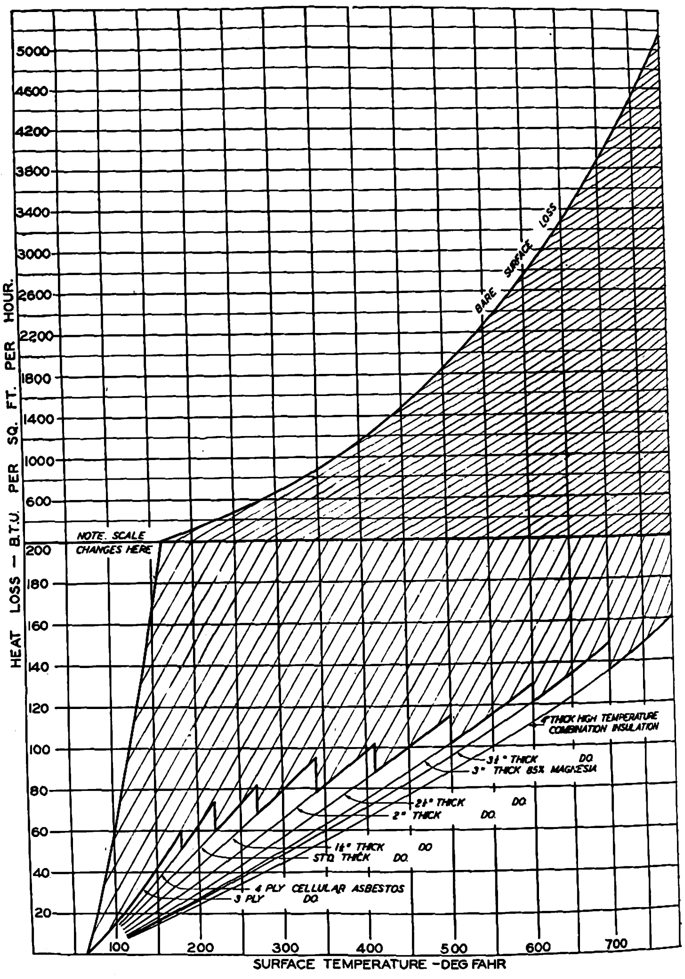

FIG. 3. COMPARATIVE LOSSES FROM BARE AND INSULATED SURFACES

These curves are based on Langmuir's† equations for convection as affected by air velocity and were selected because of Langmuir's most complete analysis of the question but many other investigators have recorded effects of air circulation that were of much greater magnitude. Therefore, it may be accepted with assurance that the heat loss at a given velocity and temperature difference will be at least as great as that shown for the stated conditions in Fig. 4.

Because of the greatly increased heat losses from surfaces exposed to circulating air, the importance of suitably insulating such surfaces is increased accordingly. This would be true even if the proportion of the heat saved by the insulation were no greater than under still air conditions. It is, however, much greater. Indeed, the effect of air circulation on the rate of heat loss through insulation is very small as compared with the effect when the air circulates in direct contact with the heated surface. This is due to the fact that air flowing over the surface of the insulation increases only the rate of heat transfer from the surface to the air and cannot change the internal resistance to heat flow inherent in the insulation itself. The effect of air circulation is to cool the exposed surface of the

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*From Circular No. 7, Engineering Experiment Station, University of Illinois.

†Transactions, American Electrochemical Society, Vol. 23.

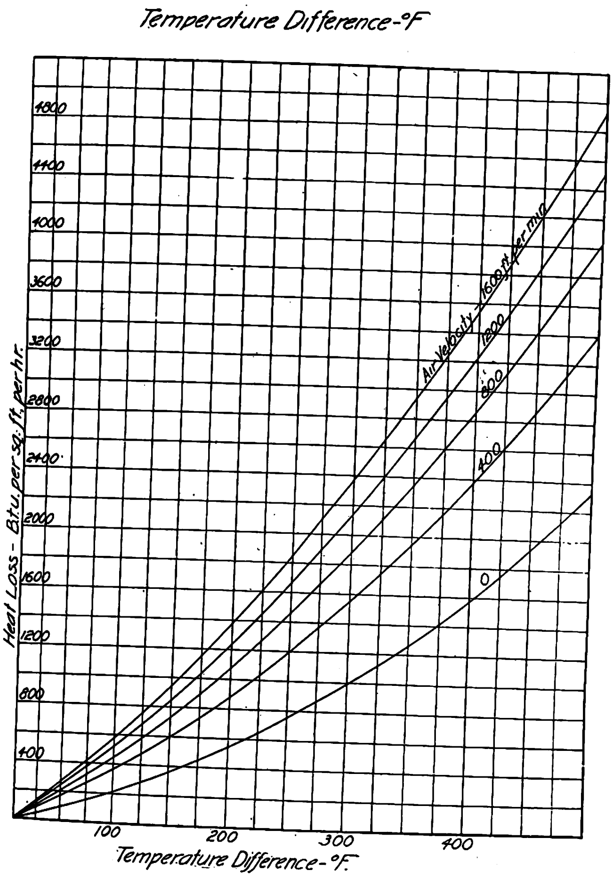


FIG. 4. HEAT LOSSES FROM SURFACES AT VARIOUS TEMPERATURES AND EXPOSED TO DIFFERENT AIR VELOCITIES

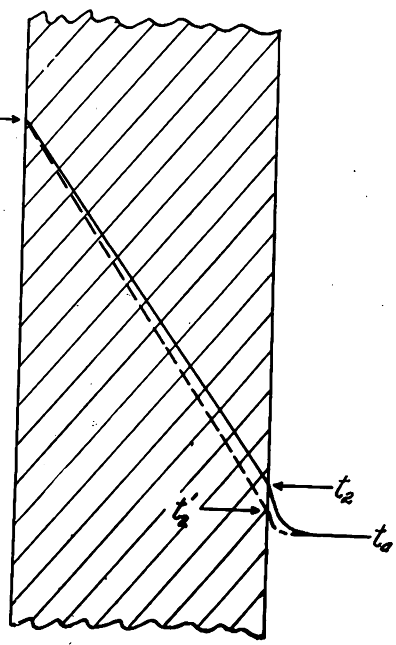


FIG. 5. TEMPERATURE GRADIENTS THROUGH INSULATION

insulation to a temperature lower than it would have under still air conditions, but since an efficient insulation already has a low surface temperature, there is little left for the circulation effect. This effect is illustrated in Fig. 5 by the decrease in temperature from t_2 to t'_2, the latter being the temperature of the surface exposed to air circulation. The heat flow, being proportional to the temperature gradient, will be increased over that for still air conditions to the same extent that $t_1 - t'_2$ is greater than $t_1 - t_2$. Therefore, for the conditions represented by the diagram, it is apparent that, even if the surface were chilled to the same temperature as the air (t_a), the increase in heat loss would not be very great. In the case of outdoor surfaces the combined effect of wind and rain may actually bring the surface temperature of the insulation practically down to air temperature yet, for the reasons given, the increase due to this extreme exposure is not as great as might be expected.

This fact is further demonstrated by the following example in which the conditions are: A flat surface, 2″ thick insulation having a conductivity of 0.5 B. T. U. per sq. ft. per degree temperature difference between surfaces per 1″ thickness per hour, and a rate of heat transfer from its outer surface under still air conditions of 1.8 B. T. U. per sq. ft. per degree temperature difference between surface and air per hour.

Internal resistance of insulation $= \frac{2}{0.5} = 4.0$

Surface resistance $= \frac{1}{1.8} = 0.556$

Total resistance $= 4.556$

Rate of heat transfer (Still air conditions) $= \frac{1}{4.556} = .22$ B. T. U. per sq. ft. per deg. temp. diff. per hour.

If the surface resistance were completely eliminated due to wind and rain, the internal resistance of 4.0 would still remain and the rate of heat transfer would be $\frac{1}{4.0} = .25$ B. T. U. per sq. ft. per deg. temp. diff. per hour. Therefore, the maximum increase due to wind and rain would be $\frac{.25 - .22}{.22} = 13.6\%$.

In like manner it may be shown that the maximum increase for 1″ thickness of the same material would be 27.9% and for 3″ thickness 9.2%. It is therefore apparent that the thicker or the more efficient an insulation is, the less its rate of heat transfer will be affected by air circulation.

All of the above discussion as to effect of air circulation on losses through insulation is based on flow of air over the surface of the insulation and applies to cases where the insulation is tightly sealed. If the conditions are such that the air may circulate through cracks and openings in the insulation, the increases may be far greater than those given above. Therefore, it is essential that all insulation be sealed as tightly as possible and that this condition be maintained. In the case of pipe insulation out of doors a weather-proof jacket amply lapped and thoroughly sealed should be provided and other outdoor insulation should be thoroughly weather-proofed.

Maintaining Temperature Head

A result of the use of insulation, which is receiving increased attention, is its effect in maintaining temperature head. In the case of superheated steam, for example, the loss of heat by radiation results in a decrease in temperature and the saving effected by insulation represents the conservation of the most valuable portion of the heat in the steam because the capacity of the steam to do useful work is dependent not only upon the amount of heat it contains but also upon its temperature. Another example of this economy, due to the maintenance of temperature head by means of insulation, which is even more striking than that just mentioned, is the case of industrial drying equipment. In this case, insulation not only reduces heat losses but, in so doing, also makes possible the maintenance of higher temperatures in a given equipment. This in turn speeds up the process and increases production. The heat which would otherwise be lost is made to do useful work, the output of the machine is increased and the labor cost and overhead per unit of product is decreased. These latter savings are often more valuable than the direct saving in steam. This is only one of many industrial processes where similar economies are not merely possible, but are actually being accomplished.

Another application of insulation which is beginning to receive the attention it deserves is roof insulation. The effect on heat economy would be a sufficient reason for giving the matter attention in connection with heated buildings but a far more pressing reason is the condensation problem present in so many industrial buildings, particularly in the paper, the chemical and the textile industries.

The Future

Undoubtedly great economies already have been effected in industry through the use of insulation and the experiences of the recent past make it safe to say that other economies are still in store. For example, a few years ago, the insulation of boiler walls was comparatively rare. Now, insulation is in general use for this service and, with the advent of the so-called "water wall," the furnace setting consists principally of the water tubes with their attachments and insulation. However, while these interesting new developments represent the broadening of the field of usefulness of insulation, there are yet many places in industrial plants, as they now stand, where important economies may be effected. Therefore, when inspecting heat equipment, the engineer will doubtless find it well worth while to bear this in mind.

Record of Conference will be continued in August issue

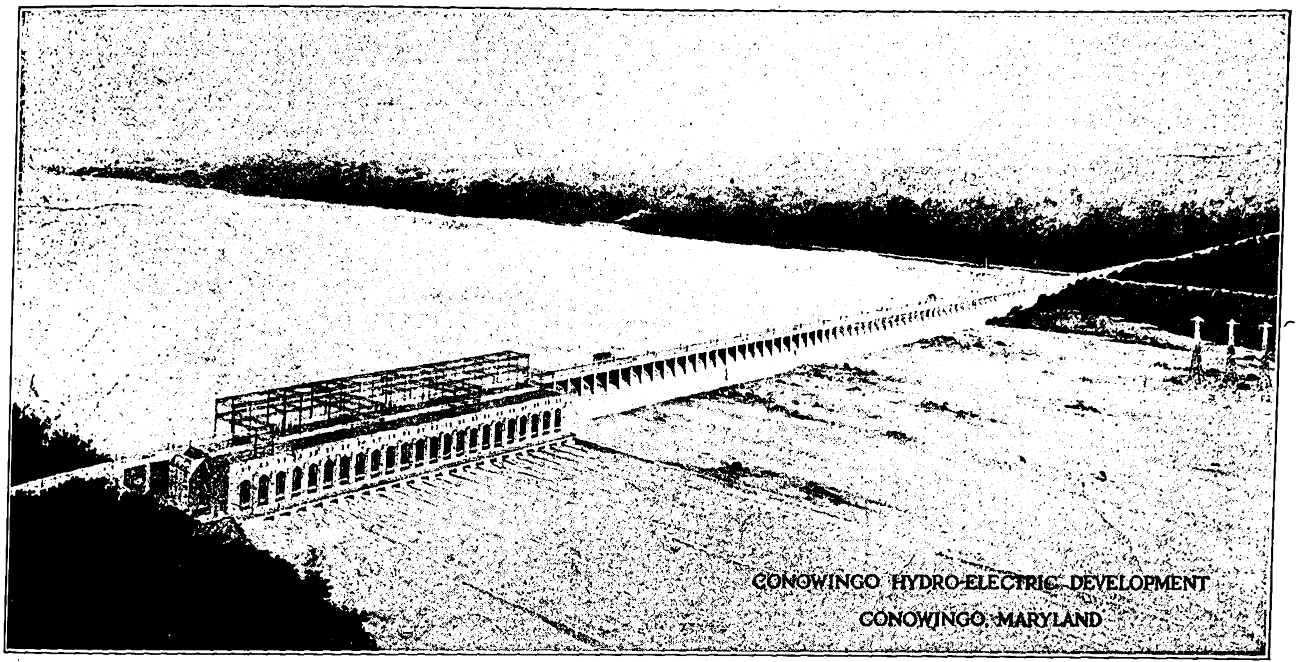
The Conowingo Project—Giant of Hydroelectric Developments

AMONG the largest of its kind in the country and, even in its first uncompleted form, second only to that of the Niagara Falls Power Company, and surpassing Muscle Shoals, will be the enormous hydroelectric plant which is being built for the Philadelphia Electric Power Company on the Susquehanna River, in the State of Maryland, within four miles of tidewater and about three miles below the present Conowingo bridge. A dam 4,500 feet long is being built across the river to form a reservoir of 8,600 acres. The impounded water will drive waterturbine-driven electric generators, the energy will be sent over high voltage transmission lines into Philadelphia, 65 miles away.

Ultimately this hydro-electric station will contain eleven generators, rated at 36,000 kilowatts, or nearly 50,000 horsepower each. The initial installation will include seven of these units giving the station 350,000 horsepower for its initial rating, as compared with the Niagara Falls Power Company development of 452,500 horsepower and the Muscle Shoals development of 260,000 horsepower. The generators are rated at 40,000 K. V. A., 90 percent power factor and 13,800 volts, with a speed of 81.8 revolutions per minute. The order for these generators is divided between the General Electric and the Westinghouse Companies and that for the hydraulic turbines is divided between the Allis-Chalmers Company and the I. P. Morris division of the Wm. Cramp & Sons' Ship and Engine Building Company.

At Holtwood, 15 miles above the Conowingo dam, there is a hydroelectric development, operating with a head of 60 feet, which supplies 500,000,000 kilowatts a year to Baltimore, 55 miles south. The theoretically available head between the Holtwood dam and tidewater is slightly over 100 feet, of which the Conowingo dam will utilize an average net head of 89 feet.

The river bed at Conowingo is of granite, assuring a firm foundation for the dam. Across the top of the dam there will be a highway, 105 feet above the foun-



ARCHITECT'S CONCEPTION OF THE COMPLETED DAM AND POWER HOUSE, AS VIEWED FROM THE SAME LOCATION AS THE COVER PICTURE. THE MAIN HIGHWAY BETWEEN PHILADELPHIA AND BALTIMORE WILL PASS OVER THE DAM.

dation, part of the main highway between Baltimore and Philadelphia, replacing a bridge which will be submerged in the reservoir. On top of the spillway, the crest of which will be 86 feet above sea level, will be 50 movable steel gates, 22½ feet high and 40 feet wide. These gates will maintain the water level behind the dam at 108½ feet above sea level. With all gates open, the discharge rate of the spillway will be 880,000 cubic feet per second, leaving an ample margin above the maximum recorded flow of 750,000 cubic feet per second.

The power house, at the west end of the dam, will be 175 feet wide and 620 feet long, with an ultimate length of 900 feet. It will be 230 feet from the bottom of the draft tubes to the top of the high tension switching station on the roof. The generators will be installed in this power house. In this connection, it is interesting to note that the bottom of the draft tubes will be 25 feet below sea level. The initial installation will include the complete sub-structure for the ultimate development.

The electric current, produced by the generators at 13,800 volts, will be stepped up to 220,000 volts by transformers and at this pressure sent over two transmission lines to Philadelphia. Each line will have sufficient capacity to carry the full load in case of trouble with the other. When the final four generators are installed, a third transmission line will be constructed.

The Susquehanna watershed of 27,000 square miles includes a large part of the central section of Pennsylvania, portions of southern New York state, and of northeastern Maryland. The average river flow is 40,000 cubic feet per second.

The Conowingo hydroelectric development will be coordinated with the great steam-turbine generating plants of the Philadelphia Electric Company, so that the water power will be used to supply the base load of the system when the flow of the river is ample, the steam stations supplying the peak loads. When the river flow is low, the steam stations will be used for carrying the base load, and the water power will be called upon only for peak loads. When the river flow is sufficient for full operation, Conowingo will supply 231,000 kilowatts for base load; when the river is low the enormous reservoir will be called upon, and statistics covering a period of 35 years show that in the driest period of the year Conowingo will be able to supply 190,000 kilowatts for peak loads. It is expected that ultimately 1,360,000,000 kilowatt-hours of energy will be produced by the Conowingo plant in the average year, saving three-quarters of a million tons of coal a year.

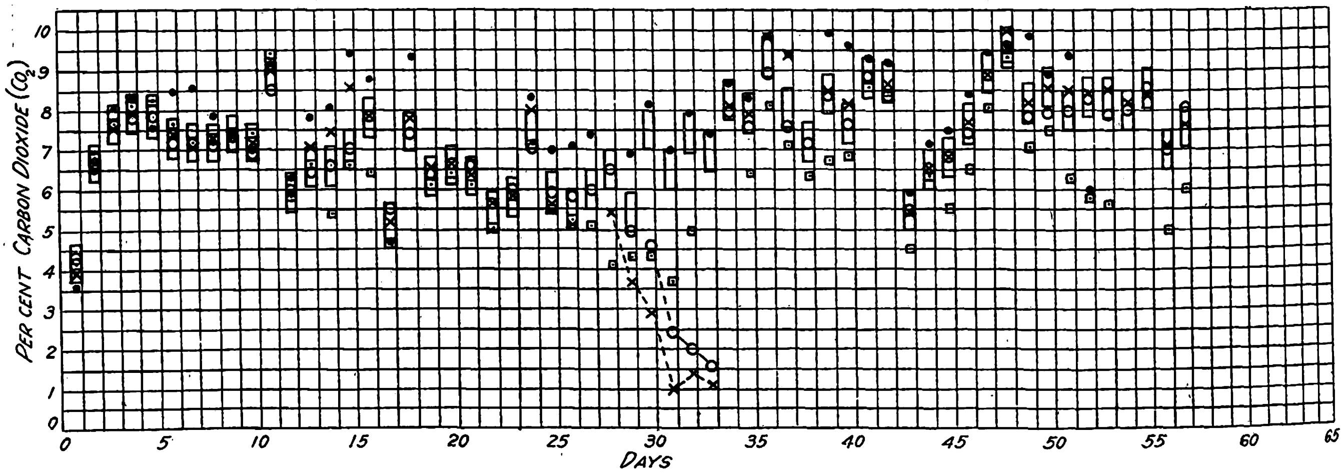
Construction of the 8,600-acre reservoir means that the little town of Conowingo, with 200 inhabitants, must be abandoned; fifteen miles of the Pennsylvania Railroad must be relocated; and five miles of the main highway between Baltimore and Philadelphia must be rebuilt.

Active work was commenced in April of this year and it is expected that power will be available some time in 1928. Although automobile travelers on the highway between Baltimore and Philadelphia can scarcely see a sign of the great changes taking place, an army of 3,000 men is at work and already the cofferdams necessary to control the river flow during the construction period are nearing completion and an enormous amount of the work has been accomplished.

A Test of CO_2 Recorders

By J. F. BARKLEY[1]

A KNOWLEDGE of the carbon dioxide (CO_2) content of the products of combustion, particularly from the boiler furnace, is very valuable. An instantaneous indication of the CO_2 can be used as a useful guide to efficient burning. A permanent record over a period of time gives a story to the management which tends to keep the operators more alert. Many instruments that indicate and record CO_2 have appeared within the last fifteen years. Inquiries as to CO_2 machines continually come to the Bureau of Mines from the general public, as well as from other branches of the Government.



Record of CO_2 Instruments. Where point falls within rectangular area, accuracy of instrument is within ½ percent.

The following test was made quite recently on four of the newer types, including one using an electrical principle. The four instruments were installed on one boiler each, according to the instructions of the makers, and the recommended routine attention was given them. The test was of a service nature, duplicating the conditions under which the instruments ordinarily serve. The boiler that was available for this purpose was practically banked for some hours of the night. This caused the average CO_2 for the entire twenty-four hours to be rather low, although it reached the higher ranges of the instruments during the day.

Each day the charts were averaged and the results plotted to form the accompanying curve. The record of each instrument is shown by its particular mark, the dot, circle, cross and square being used. In addition, there is plotted for each day a rectangular area representing 1% CO_2 in height. The proper position of this area was determined by means of the Orsat. Where the plotted point for an instrument falls within the rectangle, its accuracy is within ½% CO_2, which is considered satisfactory. Where it falls outside the rectangle, inaccuracy is indicated.

A study of the curve will show that, for the first few days, all the instruments were giving acceptable accuracy. Where a point does not appear for the day, the instrument did not give a record due to some of its own difficulties. At the place where certain points of the curve drop quite low and are connected with a dotted line, new chemical solutions were needed. This can not be charged against the instruments, as the change was delayed for the purpose of seeing the effect. One type gave continual trouble. The company's service man fixed it up on several occasions, certain changes were made according to his recommendations, but it would soon cease to function properly. No especial attentions were given the other three. At the end of the test two instruments were operating satisfactorily.

Determinations were also made as to the lag or length of time required for an instrument to indicate correctly major changes in the CO_2 content of the gas in the boiler. Factors affecting the lag are the length and size of pipe from the boiler to the instrument, the amount of gas being drawn through the pipe, and the action of the instrument itself. The instrument should be set as close to the boiler as possible. This is particularly true of the instruments that do not pull much gas through the line. Where there is much piping to reach the instrument, an auxiliary aspirator can be used to speed the gas through it. The lag in the instrument itself is affected by adjustments on the instrument. The following figures give an idea of lag values.

With 50 feet of ½" gas pipe ahead of the instrument, the CO_2 content of the gas sampled was changed from 10% CO_2 to 0%. The length of time to show correctly this change varied with the different instruments from four to twenty minutes.

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[1] Fuel engineer, Bureau of Mines, Department of Commerce.

In general, the CO_2 instruments on the market give accurate results when all elements are favorable. There are many little things that might happen to disturb the accuracy. Most of these troubles are easily corrected. Some types are much more susceptible than others to these troubles. Some are equipped with trouble-saving devices that give more trouble than they save. Simplicity is highly desirable.

Unless full confidence in the accuracy of the instrument is maintained, it will soon be lying idle. In order to maintain this confidence, two things are necessary: A certain type of man and a good Orsat. The man must be one who enjoys working with an instrument, and will learn every feature, so that there is nothing mysterious or uncertain about it. This is required of a man who cares for engines or stokers. The CO_2 instrument is a small machine of like nature.

NEW BOOKS

BOOK REVIEWS

Transport Aviation—By Archibald Black, Air Transport Engineer. 245 pages, 107 illustrations, 5½ x 8½. $3.00.

This book is for the engineer in charge of operations, as it gives detailed technical data on every phase of equipment and upkeep, as well as much valuable information on design, operation and maintenance and finally, for any one who in any way has anything to do with transportation. It is also for the investor who is interested in promoting airlines, either present or prospective, in that it gives complete and accurate figures for all costs and returns in air transportation. The text is illustrated with many photographs of transport airplanes, engines and equipment, as well as maps, graphs, and advanced designs of freight and passenger types.

Highway Curves and Earthwork—By Thos. F. Hickerson, Professor of Civil Engineering, University of North Carolina. 382 pages, pocket size, flexible, 46 diagrams. $3.50.

A compact presentation of the allied problems of highway location with special emphasis on the subject of curves and earthwork, including the banking and widening of pavements. The advantages of easement spirals are fully explained and a large variety of original tables are presented to facilitate the layout of these curves.

Alternating Currents—New Third Edition—By Carl Edward Magnuson, Professor of Electrical Engineering, and Director, Engineering Experiment Station, University of Washington. 611 pages, 6 x 9, 522 illustrations. $5.00.

A discussion of fundamental principles of alternating currents, with illustrations of their application to industrial problems. The book aims (1) to give a clear concept of what actually takes place in alternating current machinery, (2) to explain the relation between the factors involved, and (3) to express the physical facts in mathematical forms so that the student can use the equations rationally in the solution of every-day industrial problems.

In this new edition the book has been thoroughly revised in the light of the progress made during the last decade.

English for Engineers—By S. A. Harbarger, Department of English, Ohio State University. 260 pages, 5½ x 8. $2.00.

A brief but comprehensive survey of the immediate uses to which English may be put by the Engineer. The book aims to teach the student how to get through an intensive study of English, the power to present his professional ideas clearly and forcefully and to possess the thoughts of others that will benefit him in developing his personality and qualities for leadership. It presents directly the principles and methods of the major forms of technical writing; includes abundant suggestions for collateral reading, and emphasizes both the practical and the cultural value of English to the Engineer.

French in Commerce—By Jean J. Labat, Professor of French, School of Foreign Service, Georgetown University; formerly of the French Embassy. 241 pages, 5x8. Cloth, $2.50.

A thoroughly practical book for one having foreign business correspondence to handle. A novel construction of the table of contents, whereby it serves, in great measure, as an index as well, adds to the convenience of reference. Just the knowledge of business French that inevitably escapes the student of the literary language is here presented clearly and in such work as to be available for constant reference. The author is a master of English as well as of his own language, so the book is free from the blemishes so often found in bilingual works.

Business and Investment Forecasting, Forecasting Methods and Their Practical Application—By Ray Vance, President, The Brookmire Economic Service, Inc. Second Edition, Revised. xii, 187 pp., 5 x 8. Index. 1925. Cloth, $2.50.

"The primary purpose in writing this book has been to serve the active business man or investor who lacks either the time or the inclination to become an expert statistician, but who wishes to shape his business or investment policies upon a sound analysis of economic conditions," from the Preface.

Essentials of Investment—the Analysis of a Bond Circular—By Frederick Carles. 84 pp., 4 x 6½. Cloth, $1.00.

From the Foreword: "The purpose of a Bond Circular is to influence investment in corporate securities. . . . The purpose of this work is to place before those who read the circulars issued by the investment bankers, or who have made investments in good securities, a general analysis of what might be termed the average of a number of bond circulars, with reasons why certain items are emphasized."

Byways and Boulevards in and About Historic Philadelphia—By Francis Burke Brandt and Henry Volkmar Gummere, with Five Original Drawings by Frank H. Taylor and more than Three Hundred Illustrations from Prints and Photographs by Lydia Flagg Gummere, Phillip B. Wallace, W. V. Chappell and Others. Sesqui-centennial Souvenir Edition, the Official Historic Auto-Guide. 320 pp., 7½ x 10. Cloth, $3.00.

Power-Factor Wastes—By Charles R. Underhill, Consulting Electrical Engineer. 326 pages, 6 x 9. Illustrated. $3.50.

A complete and practical discussion of power-factor wastes, their costs, causes and cures. The book analyzes the use of electric power in relation to the work it is supposed to do and the work it actually does, and explains the methods which have proved successful in reducing the obvious wastes and losses. Every side of the power-factor question is given adequate attention—corrective measures and machines are thoroughly described—possible savings are shown by actual figures from plant operation. The information given will be of practical value to the manufacturing executive, the plant engineer, the electrician, and to all others interested in the economical use of electric power and the reduction of plant costs.

Belt Conveyors and Belt Elevators—By Frederick V. Hetzel, M. E., Member American Society Mechanical Engineers; Member Franklin Institute of Pennsylvania. xi, 333 pp., 5½ x 9. Cloth, $5.00.

"This is intended to be a practical book. It is not a mere restatement of what already appears in trade advertisements, nor does it contain descriptions of installations of conveying and elevating machinery. It aims rather to explain principles and the reasons for doing things. . . . The aim has been . . . to be useful to men who have material to handle and who want to know more of the "how" and "why" of conveying and elevating by belts than can be told in the catalogues and advertisements of manufacturers. The information will be of use also to consulting engineers who have to advise in the selection of the proper machinery to do certain work, to engineers and draughtsmen who design such machinery, and also to students in technical schools and colleges." From the Preface.

Practical Mathematical Analysis—By H. von Sanden, Prof. Mathematics, University of Clausthal. With Examples by the Translator, H. Levy, M. A., D.Sc., F. R. S. E., Prof. Mathematics, Imp. Coll., Science and Technology, London. xvi, 195 pp., 5½ x 8½. Cloth, $4.50.

"The mathematical courses followed by the engineer ought to provide him with a tool he is able to use to advantage. This implies that his studies must not be limited merely to attendance at classes in theoretical mathematics, but that a thorough training in practical analysis is also a real necessity." This statement, from the preface expresses an obvious truth, and, at the same time, calls attention to a lack in the engineering courses at most of our technical schools which this book is well fitted to supply.

Mechanics of Machinery—Part II—Kinematics and Dynamics—By Robert C. H. Heck, Professor of Mechanical Engineering, Rutgers University. 550 pages, 6 x 9. 658 illustrations. $5.00.

The second part of a two-volume treatise covering the whole field of motions and forces.

The book discusses the kinematics of variable motion, including all determinations of velocities and accelerations, and the study of force actions.

It covers such subjects as the kinematics of displacement, velocity and acceleration, the graphics of machine forces, the mechanics of the piston engine, vibration, balance testing and gyrostatic action, friction and lubrication and engine governors.

Some information, not available up to now in adequate form, included in this book is that on—the theory of lubrication that began with Reynolds, the work of Stribeck on ball bearings, Barth's theory of belt action.

Practical Calculus for Home Study—By C. I. Palmer, Armour Institute of Technology. 443 pages, pocket size, flexible. 186 illustrations. $3.00.

Here is a plain, clear and thorough book that will give the practical man the ability to make use of the work. The author says in his introduction: "The subject of calculus cannot be made *easy*, but it can be made *plain*." To this end he has written this book.

Gasoline Automobiles—By James A. Moyer, Director of University Extension, Massachusetts Dept. of Education. 261 pages, 5½ x 8. 212 illustrations. $2.00.

If you want to know the uses of the numerous parts of your automobile, so that you may anticipate repairs—

If you want to know when troubles occur, where to look for them and how to correct them—

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ENGINEERS & ENGINEERING

AUGUST 15, 1926

Vol. XLIII FOUNDED 1879 No. 8

Business and Banking

SOME months ago one of the large statistical organizations plotted a curve showing the country's production of electricity by kilowatt hours on a chart showing the trend of the nation's business, and the two lines traveled an almost identical course. And since this chart covered a number of years, during which business in general was both very good and very poor, it was regarded as almost conclusive evidence that the volume of electrical production is one of the surest indexes of the volume of business, and that the business outlook of the electrical utility companies is one of the most dependable guides that we have for business forecasting. There can be little doubt about this, and its great usefulness comes in the ability of the men in charge of large electric generating properties to foresee the needs of those whom they serve, and by announcing this, convey to those who study these things a definite idea of what may be expected of business as a whole, to the extent, of course, that the electric light and power business is reflective of it.

* * * *

In industrial and other districts of density of population the electric light and power business is highly prosperous, with positive and potential demands that have brought about the construction of new generating stations of considerable magnitude. In this general eastern district such plants as the Kearny station of the Public Corporation of New Jersey, the Wallenpaupack hydro plant of Pennsylvania Power and Light Co., the Conowingo development of the Philadelphia Electric Co., the new large turbine generator ordered by the New York Edison Co., the Toronto station of the Penn-Ohio Edison system, the new plant of the Cleveland Electric Illuminating Co., at Avon Beach, and others, are simply indicative of the expectations of those high in the electrical industry. And if this is a guide to the future of business, and it probably is, then the prospects are that business is going to be very good for an indefinite time. There will of necessity be variations—the business curve has never yet followed a straight course, but the general trend will be toward activity in volume. At any rate there is little in sight now to occasion belief that business may not continue to be as good as it is, although there are bound to be the seasonal variations and other ups and downs in various departments. At this time (August 1st) agriculture as a whole is producing huge crops with prices of such crops fully compensatory. Coal mining, however, in Central and Eastern territory is inactive, and likely to remain so for from six to nine months longer. There is no pronounced shortage of coal, but the industry has impaired its own welfare and has brought about a shift of prosperous operation from the territory north of the Mason and Dixon line to the coal areas south of it. When this is adjusted and the business is more evenly divided, there will also be a division of the businesses of all who thrive through activity in coal mining, including the railroads, of whose activities the coal movement is so large a part.

* * * *

One of the surprises of July was the refusal of the Interstate Commerce Commission to grant freight rate increases to the railroads operating in Northwestern territory. With two important roads in receivership, and with most of the others earning less and paying smaller dividends than formerly, and with steamer lines using the Panama Canal largely increasing freight carrying capacity, the Commission expressed the opinion that the railways were doing well without an increase in rates and refused to approve one. Based upon the results of recent years these companies have done fairly well of late. 1925 was their best year since 1917, with the first six months of 1926 about one-third larger, in gross income, than the first half of last year.

In other respects reports indicate that the volume of freight movement holds, and with a large harvest in prospect and good business with manufacturers of commodities of many kinds, this seems likely to keep up for the balance of the year and perhaps longer. Improvement in the net earnings of the railroads has been particularly noticeable, this showing the results of business aggressiveness, operating economies, better organization, greater efficiency, etc. The railroads, however, have not been large buyers of materials and supplies and their partial absence from the markets has been a subject of some comment.

* * * *

Orders booked by the United States Steel corporation during the seven months ended July 31 exceeded those of the same period during 1925 by about 12 per cent and there are indications that during the coming months the increases will average larger. With this corporation the rate of ingot production at the end of July was nearly 90 per cent.

Southern furnace interests were in about the same situation. Birmingham reported orders on hand sufficient to utilize the bulk of output for the third quarter of the year, export demand being an important item.

Local independent companies have experienced expanding demand for steel sheets, tin plates, etc., urgent requests for shipment showing that consumers' inventories are low. Logically prices average firm to strong.

* * * *

Bankers for Dodge Brothers, Inc., say that the gain in all automobile production in the United States and Canada for the first half of this year was twelve per cent larger than for the first half of last year. They show a total production, cars and trucks, of 2,449,192 during the six months to June 30, 1926, to compare with 2,186,059 for the first half of 1925.

Sales by mail order concerns are considered to be reflective of the cash position in the country. Sears Roebuck & Co. report that sales during seven months to July 31, this year, totalled $146,633,302 an increase of $11,317,436 over 1925, or a gain of 8.3 per cent. Montgomery Ward & Co.'s percentage of gain was somewhat larger.

* * * *

Dun's reports that the July record of 1,605 commercial failures in the United States was the smallest for any month since October, 1925. In seven months of this year there were 13,081 defaults for liabilities of $239,600,000, which compares with 13,105 defaults for $273,900,000 during the same period of a year ago.

The banking situation during July showed little change over June. Money remained easy until the last few days of the month when the rate on call loans stiffened to 5 per cent. This, it was explained was in large part due to the subscription to the new issue of $157,000,000 additional capital stock by the American Telephone and Telegraph Co., whose first instalment payment came due August 2. It was estimated that over $130,000,000 was transferred from all parts of the United States to New York for this account.

Some further tightening in rates is to be expected, because this is the period of money movement for harvest financing. On the other hand, employment conditions are excellent and people are saving a good portion of what they earn. In this latter connection The Federal Reserve Bank advises that in the Philadelphia Reserve District savings deposits in 99 reporting banks increased from $591,881,000 on June 1st to $594,694,000 on July 1, a gain of $3,083,000 or one-half of one per cent. This gain was partially accounted for by the crediting of interest amounting to $1,963,000.

* * * *

The stock market, at the close of July, was slightly higher in its general price level than at the close of June. There were spectacular movements, especially in General Motors and United States Steel Corporation stocks and pronounced strength in the capital issues of public utility companies. The volume of transactions was large—unusually so for one of the summer months and the general trend of quotations upward. Experienced opinion is toward price recessions during August. The reasons for this are undoubtedly that prices have been moving generally upward since March, that the price chart shows quotations on the average to be fairly high, and that speculative reaction may be desirable.

Good investment bonds were not as active on stock exchanges as formerly, and this may easily be accounted for by scarcity. New issues introduced during the month were immediately taken in the instances of prime names, while there was ample demand to absorb the good issues yielding better income. Over-the-counter business of the banking houses was unusually good for July.

An interesting announcement made during the month was to the effect that a total of $420,000,000 issues of bonds secured upon real estate properties were underwritten and sold in the United States during the first six months of this year.

FREDERICK CARLES.

Items of Interest

Protection of Oil Tanks from Lightning

The oil fires in California, which resulted in the destruction of more than $10,000,000 in oil and property, were attributed to lightning. The lightning hazard is well known to the oil industry, and studies of protection methods have been made.

Oil storage tanks are necessarily so large that reinforced concrete, rather than metal, tanks must usually be used. These concrete reservoirs are frequently 500 feet in diameter, and sometimes in oval form as large as 600 by 1200 by 30 feet deep. As many as 25 or more such tanks sometimes make up a "tank farm." The tops are of wood, often covered with felt as a protection from the heat of the sun and evaporation.

Very frequently, especially with certain types of oil, the space between the surface of the oil and the top of the tank becomes filled with an explosive mixture of air and oil vapors. In general, no lightning protection is used.

F. W. Peek, Jr., Consulting Engineer, speaking at the annual meeting of the American Petroleum Institute in Los Angeles last January, described experiments which had been made in the Pittsfield laboratory with artificial lightning and miniature oil tanks, and told how protection from direct hits by lightning can be secured. The following, written from notes made during Mr. Peek's address, are of interest in view of recent oil fires.

"In considering oil tanks, two cases must be kept in mind—the tank containing explosive mixtures and the tank free from such gases.

"Where there are explosive mixtures, the protection problem is exceedingly difficult. Just as a considerable voltage may appear on electrical transmission lines a mile or more from the lightning discharge, because of 'wireless' or induction effect, so may sparks be caused by voltages induced in metal parts of the tank, even though the tank is not struck directly by the lightning. A spark at 500 volts, caused by a lightning stroke several miles away, could ignite the mixture.

"If a tank were made completely of insulating material, there could be no spark, but there are always pipes, nails, conducting strips, etc., more or less isolated. Grounded wires strung over the tank, as in the case of a protected transmission line, would reduce the voltages; a grounded two-inch net cage would reduce the voltages to about one-tenth. The hazard would be reduced, but it would only mean that the storm would have to come closer to cause the little spark. The only safe method where there is explosive gas is a complete metal tank, inside of which no sparks can occur. Even then, however, there is danger when projections extend from the surface.

"Where explosive mixtures of gases can be kept from the tank, the chance of induced voltages causing trouble is small. Direct hits, however, could set the oil-soaked roof on fire. There are a number of principles, discovered in the Pittsfield laboratory, that can be applied to prevent the tank from being struck. It has been found, for instance, that lightning never strikes the ground nearer a conducting rod than four times its height. If the lightning does not strike the rod, then it hits the ground some distance away. A number of rods properly placed about the tank would either take the hits or cause the lightning to strike the ground some distance away. Grounded wires strung over the tank, a grounded metal net or metal roof, afford protection against direct hits. A tank made completely of metal is also ideal.

"The researches, which showed that a man standing has 15 times the chance of being struck that a man flat on the ground has, showed that a storm discharging over a tank farm is likely to strike a tank. It also showed that the edge of a small tank will always be struck, while the very large tanks may be hit anywhere.

"The investigations also showed that explosive gases may be set off by sparks produced by means other than lightning as, for instance, static sparks produced by friction."

Twenty-five Percent of Over 300 U. S. Cities Have Metered Water Service

A survey of water supply rates in the United States during the past year revealed the fact that metering of water is rapidly becoming general throughout the country.

Of the more than three hundred cities that responded to questionnaires sent to water-works superintendents, fifty-one per cent reported that their services were one hundred per cent metered. Only fourteen out of the three hundred cities reported no meters in use. More than ninety-five per cent reported some use of meters.

Forty-seven per cent of these cities use cubic feet of water as the basis of their charges and the other fifty-three per cent use gallons. Most cities have a sliding scale of rates, depending on maximum rates of consumption.

An increasing number of cities are making a fixed charge, called a "service charge," independent of the amount consumed, and add to this the consumption charges.

—*News Bulletin.*

International Conference on Coal

An international conference on coal will be held at the Carnegie Institute of Technology in Pittsburgh, the end of November, 1926. The fundamental idea of the meeting is the discussion of new uses of bituminous coal.

Several prominent scientists of Germany, France and England have been invited to participate in the discussions, and in addition, papers will be presented by a number of leading American engineers and scientists representing the latest discoveries in connection with the distillation of coal, its by-products, new methods of producing; energy from coal; the low temperature carbonization of coal; generation of power at the mines; domestic use of coke, and water power vs. coal energy.

AMERICAN ENGINEERING STANDARDS COMMITTEE

Standardization of Engineering Symbols and Abbreviations

Under the auspices of the Committee, a large project which will lead to the eventual standardization of scientific and engineering symbols and abbreviations, has been fairly launched.

The larger groups of the work planned for early attention, and on most of which sub-committees have been organized and are actively at work, are the following:

1. Mechanics, Structural Engineering and Testing Materials.
2. Hydraulics.
3. Heat and Thermodynamics.
4. Photometry and Illumination.
5. Aeronautics.
6. Mathematical Symbols.
7. Electrotechnical Symbols and Abbreviations, including Radio.

The secretary of the sectional committee, Preston S. Millar, 80th Street and East End Ave., New York, will be pleased to receive the co-operation of interested organizations and persons specially interested in the general subject, or one of the above subcommittee topics. Groups of symbols, or abbreviations, on these subjects which have been proposed, or adopted, in various fields of engineering or industry, or other work within the scope of the sectional committee, may be communicated to him.

It will be realized that the whole of the work before the sectional committee will require participation of a great many interested individuals, and groups, and a long time for its completion. The present plan is to concentrate upon those fields in which the need for unification is most pressing, or in which material that may underlie a future standard is already in existence, and can be readily put into form for study, circulation and formal adoption.

School Room Ventilation

An article in the American Journal of Public Health by Leonard Greenburg, Associate Engineer, U. S. P. H. S., gives the history of ventilation, a resumé of the State Ventilation Laws for school buildings, and a discussion of the advantages and disadvantages of the types of ventilation and standards which have been employed.

In some of the states a change to the window system of ventilation would conflict with the local laws. Engineers and Architects interested in the best methods of ventilation should use every effort to revoke present laws so as to permit the selection of the best type of ventilation and the maintenance of a temperature of from 65 to 70 degrees F. during the heating season.

The use of the window-gravity system of school ventilation is advocated in preference to the fan system. Among the reasons given for preferring the window system are: (1) Lower first cost; (2) Lower maintenance and operation cost; (3) Disuse of the Fan System after installation; (4) Simpler supervision and operation; (5) Unsatisfactory design of the Fan System.

Electrified Farms in U. S. Increasing at Rate of Thousand Every Month

More than a thousand farms a month are being added to the various service lines of the electric light and power companies in the United States and the rate is steadily growing.

The increasing use of electricity on farms is made economically possible by interconnection of transmission lines. One big obstacle that has limited the extension of rural electric service is the fact that only two or three farms can be served by one mile of power line.

In the state of Pennsylvania more than 17,000 new customers were added to rural electric lines in 1925. That is 10½ per cent of the total of new customers added by the industry during the year throughout the whole state. It is estimated that at present 250,000 farms in the country are supplied with electric service.

Seventeen experimental lines have been built in seventeen states and are serving as field laboratories. They are devoted largely to determining possible uses and also analyzing costs of supplying electric service. —*News Bulletin.*

Bus Fails to Supplant Electric Car in Cities That Have Made Tests

The erroneous impression that the bus is supplanting the electric car is doubtless due to the failure to give details regarding the size of abandoned rail operations, according to Lucius S. Storrs, Managing Director of the American Electric Railway Association.

"When it was recently proposed to substitute buses for cars carrying about two per cent of New York City's surface car riders, many hailed the suggestion as meaning the passing of the trolley in New York," said Mr. Storrs. "Trolleys are carrying one-third of all New York riders. Subways carry most of the rest.

"A special dispatch from Texas recently told of substituting busses for cars on the Brownsville line. The story did not tell that the abandoned property consisted of only two cars and two miles of track.

"The attempt to substitute busses for trolley service has been tested in a number of American cities of more than 50,000 population. All have returned to the electric car. Among these cities are Des Moines, Akron, Bridgeport and Saginaw. The fact that no city in the world of more than 50,000 population is being served exclusively by busses proves the need for the street car."

The Engineer and the Lumber Industry

In an address before the Seattle Convention of the American Society of Civil Engineers, on July 14, 1926, Mr. J. J. Donovan of Bellingham, Washington, pointed out the fact that the engineer is a very important factor in the lumber industry, not only in solving problems in production and use of lumber, but also in the matters of sane, sensible selling. At present the primitive methods of logging the timber and sawing lumber have been replaced by modern means, especially in carrying on this great industry in Washington and Oregon.

The payroll of the lumber industry in these two states is greater than the combined payrolls of all other industries which are subject to state industrial insurance.

At the present rate of cutting, the forests of Washington will last fifty years and those of Oregon for one hundred years, allowing nothing for new growth. The common sense of the engineer if applied to the problems of this industry will help materially in extending the life of the forests. He has already made his mark in the woods, at the mills and docks. Labor-saving devices of many kinds, package handling, conveyors, steam and electric cranes, all do their share to give the men of the northwest the best pay and the shortest hours of any lumbermen in the world.

Oil-Electric Locomotive in Mine Work

The oil-electric locomotive is to make its appearance in the mining field. The Utah Copper Company has ordered one of the 60-ton type for use at its Bingham, Utah, mines.

This locomotive is to be installed purely in the interest of economy of operation. Engineers of the producing companies estimate that the oil-electric will save four cents on every ton of ore and waste rock it hauls from the mines.

At present there are 57 steam locomotives at the mine hauling from it over 30,000,000 tons of material each year. Based upon an average of 526,315 tons hauled by each locomotive during the year, the saving effected by the oil-electric, at four cents a ton, would run to $21,052.60 on its year's work.

If oil-electric were substituted for the entire 57 steam locomotives, the saving on the 30,000,000 tons of haulage would be over $1,200,000 a year.

The oil-electric will take its place with the steam locomotives, or "saddle-backs," in working along the winding switch-back roads that girdle the mountain, hauling cars up and down, and switching the loaded ones to side-tracks, ready for the process of extracting the ore from the rough stone.

Oil-electric locomotives are in use on four railroad systems in the East, while other systems in the East and West have placed orders for them.

Aside from the saving in fuel, through the use of heavy grade oil, the oil-electric makes further economy possible through the elimination of roundhouses, turn-tables, water towers and troughs, hostling service and the handling of coal and ash pits, all of which run up the steam locomotive's cost of maintenance. Interesting data and actual cost figures can be obtained upon request of ENGINEERS AND ENGINEERING.

Aircraft Progress to Be Discussed

Latest developments in airplanes and aviation are to be discussed at the annual aeronautic meeting of the Society of Automotive Engineers, to be held in Philadelphia at the Bellevue-Stratford Hotel, on Sept. 2 and 3, immediately preceding the national air races, which are to be held consecutively from the fourth to the eleventh.

There are to be three technical sessions, an aeronautic banquet the evening of Sept. 2, at which the principal speaker is expected to be a man who is famous for his recent achievements in aeronautic activities, and an inspection visit by the members and their guests on the afternoon of Sept. 3 to the Naval Aircraft Factory at Philadelphia, where a special exhibition of equipment and performance is promised.

At the technical sessions there are to be addresses as follows:

Aircraft Engine Developments, by Commander E. E. Wilson, aircraft engine division, Bureau of Aeronautics, United States Navy.

Air-Cooled Engine Developments, by G. J. Mead, Pratt & Whitney Aircraft Co., and E. T. Jones, Wright Aeronautical Corporation.

Production of All-Metal Airplanes and Seaplanes, by Dr. Adolph Rohrbach, Berlin, Germany.

Planes for Individual Ownership, by Elwood Junkin, Waco, Tex.; Edward Stinson, Stinson Sales Corp.; A. V. Verville, Buhl-Verville Aircraft Co., and a representative of the Travel Air Mfg. Co.

How I Fly at Night, by W. L. Smith, Air Mail Service pilot.

Airway Illumination Equipment and Methods, by C. T. Ludington, B. B. T. Corp. of America, and H. C. Ritchie, General Electric Co.

Direction Finding by Radio, by Lieut. L. M. Wolfe and Capt. W. H. Murphy, Air Service radio laboratory, McCook Field, Dayton.

The program and arrangements for the meeting are in charge of a committee composed of W. B. Stout, Stout airplane division, Ford Motor Co., Detroit, chairman; Paul Henderson, general manager National Air Transport, Washington; Glenn L. Martin, president Glenn L. Martin Co., Cleveland; Ralph H. Upson, chief engineer Aircraft Development Corp., Detroit; E. P. Warner, professor of aeronautical engineering, Massachusetts Institute of Technology, Cambridge, Mass.; and J. E. Whitbeck, vice-president Wm. E. Arthur Co., New York.

NATIONAL INDUSTRIAL CONFERENCE BOARD, INC.

Increase in Home Markets

The United States, in mere population growth during the past five years has acquired more consumption power, or new potential markets, than if she had taken into her confines the entire population of Canada. Canada in 1925 ranked second only to Great Britain as a customer for American exports. The recently estimated population increase of 10,229,000 during the five years 1920-25 is 15 per cent more than the population of Canada.

The total purchasing power of the people of the United States has increased considerably because of the generally reduced cost of living and the resultant higher "real earnings" since 1920, leaving a greater margin of surplus after the purchase of necessities. This is clearly reflected in the growth of savings of the American people, the accumulation of which has strikingly accelerated during the past five years as compared with previous years. Individual deposits in saving banks per capita in 1900 were $31.44; in 1925 were $78.19. Life insurance policies in force per capita in 1900 were $112.66; in 1925 were $621.01. Building and Loan Association assets per capita in 1900 were $8.27; in 1925 were $41.11.

Results of Road Impact Tests

Some deductions drawn from data obtained by the Bureau of Public Roads in a series of tests of motor truck tire impacts on road surfaces, extending over the last two years and carried out in cooperation with the Society of Automotive Engineers and the Rubber Association of America, were given in an address at the summer meeting of the Society during the first week in June.

These conclusions are that the impact reaction, or force of the blow, increases as the weight supported by the tire is increased but that the ratio of the reaction to the weight becomes less as the weight is increased; that the narrower the tread rubber of solid tires is, the less is the impact reaction and that increasing the height of the tread rubber has a marked effect in reducing the impact reaction in both single and dual tire mounting; that dual tires cause greater impact forces than single tires of corresponding load capacity; that breaks in continuity of the tread surface cause heavy repeated road impacts, and that dual tires should be mounted with the tread design staggered.

In the tests the vertical reactions from road obstructions were measured by a specially constructed instrument called an accelerometer mounted on the truck and designed to measure the force and speed of upward thrusts and at the same time to measure the proportional deflection of the truck spring adjacent to the wheel.

The results show that pneumatic tires may make a rough road seem reasonably smooth and solid tires in poor condition may make a smooth road seem unreasonably rough. A few tests indicated that no great difference in effect was produced by varying the unsprung weight, that is, the weight of wheel, tire and axle below the vehicle spring supporting the frame and its load.

From a cushioning viewpoint, the combination of a low pressure balloon tire or an underinflated high pressure pneumatic tire, a relatively heavy unsprung weight, and a comparatively flexible truck spring, might eliminate all but the severest road roughnesses.

A change in mounting dual tires having a very deep non-skid design, so that the depressions in the two tire treads were staggered instead of being opposite each other, resulted in reducing the impact reaction from 3,600 pounds to 1,200 pounds at each repetition of the tread design on a smooth concrete road. The greatest impact reactions occurred with all the trucks at speeds between twelve and fifteen miles an hour. The impact force with pneumatic tires had a duration of 8/1000 of a second, and with a wornout solid tire of about 2/100 of a second.

DEPARTMENT OF COMMERCE
Washington

The Quality of Motor Gasoline Remains Uniform

The quality of motor gasoline sold in the United States in the past few years has undergone very little change, the Bureau of Mines finds as the result of special surveys made in the larger cities semi-annually. There is no necessary relation between the gravity of a gasoline, and its volatility or utilization as a motor fuel. Whether gasoline in the future will have approximately the same characteristics that it has had since 1920 will depend to a great extent on whether it will be necessary, or desirable, that it have those characteristics. This question is bound up in the topic of automotive developments.

There is a distinct advantage in using a motor fuel as heavy as can be utilized by the engine, in that the energy content of a heavy fuel is in general larger in terms of B.t.u. per gallon than a lighter fuel. Motor fuels are almost exclusively sold in this country on a volume basis. Another factor is that the demand for gasoline is enormous, and everything which can be made to serve as motor fuel will, sooner or later, have to be so used. When crude oil and gasoline are as plentiful as they have been during the past few years, there is not the incentive to the most economical utilization. This is not to say that considerable progress has not been made in increasing the yield of gasoline and other valuable products from crude oil. Refining equipment used by progressive refiners is constantly being improved, and is measurably superior to what it was even five years ago.

National Committee on Metals Utilization

Organization of a movement in the United States by users and manufacturers of metals to hunt down and reduce the wastes in the metals-using industries by bringing about voluntary cooperative action for better utilization, which would be of resultant benefit to the general public, was undertaken at a conference held by the National Committee on Metals Utilization in the Department of Commerce.

Representatives of professional, technical and trade organizations and industries manufacturing and utilizing metals, constitute the personnel of the Committee to attend the conference. Secretary Hoover has consented to serve as chairman. W. C. Wetherill, of Philadelphia, is director of the Committee.

Numerous and only slightly differing varieties and sizes now being manufactured, and specified by users, tend to increase waste and production costs in the metals industries and thus impose a consequent burden generally, Mr. Wetherill explained in outlining the opportunities for better utilization. Definite plans for dealing with the problem, and projects with which to proceed, will be devised by the Committee.

Wrought Iron and Wrought Steel Pipe, Valves and Fittings

Simplified Practice Recommendations, developed by the industry, reducing the sizes and dimensions of wrought iron and wrought steel pipe, valves and fittings, were adopted on May 28th, 1926, at a general conference of representatives of manufacturers, distributors and users of these products, held under the joint auspices of the Division of Simplified Practice and the National Committee on Metals Utilization of the Department of Commerce.

The recommendations, it was voted, are to become effective September 1, 1926, for new production, and January 1, 1927, for existing stocks; and will be subject to regular annual revision by a standing committee representative of all three groups. Copies of the simplified lists should be available from manufacturers, or may be obtained from the National Committee on Metals Utilization of the Department of Commerce.

The sizes and dimensions included in the recommendations were felt to be adequate to meet all normal needs, and should afford greater convenience than was possible with the former large number of sizes. It is hoped that engineers, architects, purchasing agents, works superintedents, real estate boards and all manufacturers, distributors and users will reap such benefits from this movement that it will become desirable to extend in this industry the principles of Simplified Practice. Such practice should decrease stocks, lower production and selling expenses, eliminate misunderstandings and improve service as well as lower costs to the user.

Fire Resistance of Hollow Building Tile.

8-Inch Walls Adequate for Residences

Tests to show the behavior of tile walls in burning buildings, which the Bureau of Standards has been conducting on hollow tile in cooperation with the Hollow Building Tile Association, were reported in a paper read before the building officials of the principal cities of the United States at their recent annual meeting in Columbus, Ohio.

These tests were planned to yield more information on the properties of hollow tile, such as the strength of tile walls, and more especially the fire resistance of such walls. This report was concerned principally with the fire tests.

Two sizes of walls were tested—one 16 feet long and 11 feet high, the other 4 feet long and 4 feet high. The walls were built just as they would be built in a building and when they had aged a month or more they were placed to form one side of the furnace in which the tests were made. The fire in the furnace was regulated during the test so as to approximate that obtained in severe fires in burning buildings.

The tests show the ability of tile walls to carry load during the burning of a building and also to prevent the spread of fire when they are used as party or fire walls. They show that 8-inch tile walls would be adequate for residence and office buildings, and institutions in which no considerable amount of combustible material is allowed to collect.

For stores or factories containing only a moderate amount of combustible material a 12-inch wall would be required. For factories having a considerable amount of combustible material, or for warehouses, a wall heavier than 12 inches would be required, particularly if the wall is not plastered.

The results of these tests are considered of great value to the industry and the public, as well as to building commissioners, in that they give reliable information on the extent to which hollow tile walls can be relied upon for protection in case of fire.

Paint and Varnish in Wood Conservation*

It is pretty generally understood that paint and varnish have an indispensable part to play in prolonging the useful life of wood, but it is not always understood clearly how and why they do so. In itself, wood is as durable as almost any other organic material, but it is subject to attack by two powerful enemies. One is a foreign invasion, the wood-destroying fungi which are responsible for decay; the other is internal dissension, represented by the weathering of the wood as a result of unequal swelling and shrinking on exposure to periodical changes in moisture conditions.

The decay and the weathering of wood differ from each other fundamentally, are not usually encountered in the same places, and must be combated by entirely different methods.

The factors essential to the development of decay are four: Temperature, air, food, and moisture. It will be obvious that, for most practical purposes, the conditions that determine the moisture content of wood in service determine likewise its liability to decay. The air supply is almost always sufficient, the temperature is usually favorable to the fungus, at least during a very large portion of the year, the wood itself is a suitable food, and there remains only the item of moisture content, to complete the conditions favorable for decay.

Paint is not itself toxic to fungi; in fact, a few fungi can even use it as a food. It is essentially a surface coating which penetrates wood very slightly. Even if a coating entirely impervious to the fungus spores were constantly maintained over the surface of the wood, the infection is almost certainly present in the wood to begin with. The influence of a paint or varnish coating on decay is again, therefore, a question of moisture content.

In so far as the paint coating retards the absorption of rain water and dampness by wood in structures it tends to keep the moisture content of the wood below the point necessary for the development of decay. But many structural conditions are likely to occur in which water can obtain access to the wood through parts which are not painted. In many cases the subsequent drying out of the wood can take place only through the exposed painted surfaces, and the paint coating tends to keep the moisture content high and thus favors decay. It would frequently help matters if some of the concealed surfaces subject to contact with rain water were painted during erection, but end-grain wood is difficult to paint, and the labor factor must always be taken into account. Repainting of such places is usually impossible. It would probably be found more practical to improve the methods of construction in such a way as to avoid crevices and pockets likely to retain rain water and, where they cannot be avoided altogether, to try to provide for quick re-evaporation.

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*Abstracts from an address by Dr. F. L. Browne delivered at Louisville, Ky.

The principal cause of weathering is frequent exposure of the surface of the wood to rapid changes in moisture content. Rain falling upon unprotected house siding is quickly absorbed by the surface layer of the wood but, before it can penetrate to the interior of the boards, the sun comes out and drying removes not only this added moisture but continues to take from the surface more rapidly than moisture can pass to the surface from the interior. The oscillations between extremes of dryness and saturation taking place in the outer layer of the wood, while the interior remains relatively constant, set up large internal stresses which give rise to weathering.

The usual cure for weathering is, of course, paint or varnish. Such coatings retard the absorption of water and the drying out of the wood to such an extent that large inequalities of moisture content within the lumber are avoided. Where wood is exposed freely to the atmosphere so that it obtains water only from the elements, a paint coating keeps the moisture content relatively constant but, where wood is exposed to water or damp air continuously for relatively long periods, a paint coating cannot be expected to keep it dry.

In the program for the conservation of our timber supply, paint and varnish provide the most effective antidote for weathering.

On the other hand, someone is occasionally found trying to use paint to save a non-durable wood employed in a place where conditions make decay almost a certainty. This is unfortunate because, when disaster results, the disappointed user is likely to discount the value of paint as a protection for wood, forgetting that, when employed in its proper field, as a protection against weathering it is remarkably effective and adds very materially to the service life of lumber.

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The writer appreciates the opportunity offered to discuss briefly the above very interesting article by Dr. Browne. He has stressed the importance of that type of decay which results from the attack of fungi. As a matter of fact, however, in the average wooden dwelling, probably not over one or two per cent of the wood is destroyed by fungi, the balance being maintained in excellent condition through the application of paint preservatives. Occasionally the under side of porches or other wooden structures subjected to warm, damp air for long periods of time, may show the type of decay caused by fungi. The fact, however, that we have hundreds of dwellings throughout New England, that are a century or two old, and which have been preserved in wonderful condition for such a period of time through the application of paint coatings, is sufficient to demonstrate the protective value of paint as a decay preventative. In this connection, it is quite proper to term "decay" that form of wood disintegration which results from the effects of weathering—the passing of the material from a sound or perfect state to weakness; the roughening; the raising of the grain; the checking of the surface; the splintering and other obvious signs of decay that are shown when lumber is left in an unpainted condition. It should also be pointed out that the corrosion of unpainted metal is a form of "decay." It is generally admitted that paint will prevent these defects, and it is therefore a preservative agent against decay. However, as Dr. Browne has pointed out, it is quite unreasonable to expect a coat of paint or any other surface coating to protect unsound lumber that may be infested with fungi and kept under conditions that favor their growth.

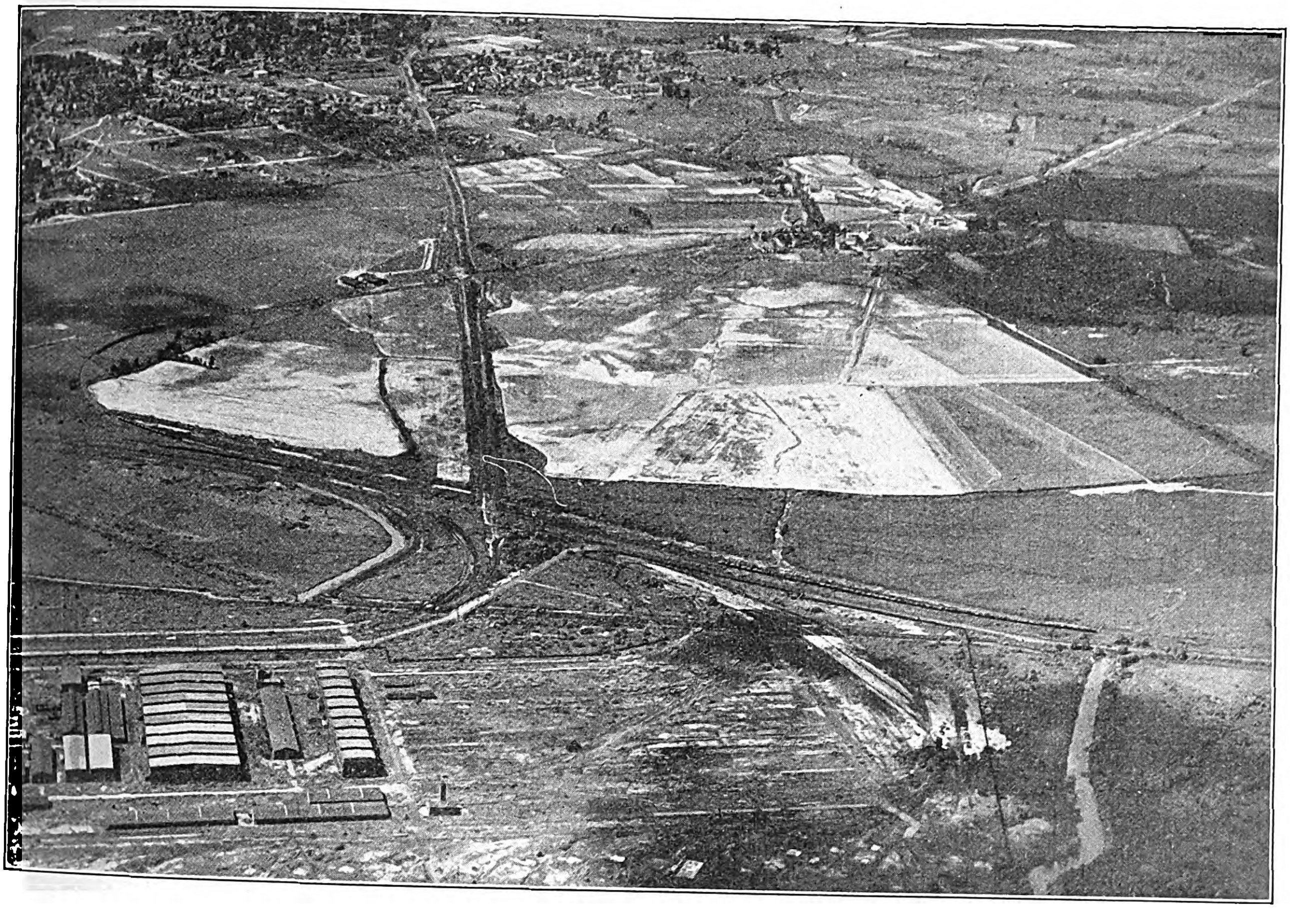
—*Henry M. Gardner, Institute of Paint and Varnish Research, Washington, D. C.*

Large Asphalt Beds Found in Philippines

A large deposit of excellent asphalt has been discovered near the coast of the island of Samar, Philippines, according to a report in "La Vanguardia," the largest Manila daily. At least 40,000,000 tons of the bituminous substance are available, declare engineers who have examined the site. A company is being formed to develop the property and is expected to begin operations within a few months.

This is the second large asphalt deposit discovered in recent years in the Philippines. The first was found on the island of Leyte and is now under Japanese control, having been sold to Japanese interests after vain attempts to interest American capital. William Anderson, an American, had the controlling interest in this property before the Japanese bought it.

The new asphalt tract is situated in the municipality of Borongan, within easy and close access of deep water navigable by ocean steamers.



Model Farm Flying Field

National Air Races

THE propellers of hundreds of speedy airplanes will be pointed toward Philadelphia and the National Air Races which will be held at the new Model Farms flying fields in southwest Philadelphia, Sept. 4th to 11th. It will be the biggest flying show ever held in America, if not in the world. Nineteen separate contests have been scheduled for the eight days of the meet. Cash prizes of $30,000, the largest sum yet put up for this annual event, will accompany valuable trophies awarded the winners.

Field Built for This Event

The airdrome at Model Farms is trapezoidal in shape, measures more than half a mile, and was built especially for air racing and for this spectacular display of aerial events. It has been constructed through an appropriation made for the purpose by the City Council, and as a part of the Sesqui-Centennial financing. Approximately $150,000 has been appropriated for the air meet and construction of the field. The flying arena itself occupies 260 acres, located at Penrose Ferry Road and Island Road. It was acquired by the city for the future location of an immense sewage disposal plant. Dikes, hillocks and other inequalities have been levelled off and the field now presents a surface as smooth as a table top. It has been planted with 60,000 pounds of millet and long stretches are now verdantly green and smooth.

Major Wehrle Directs Work

More than two miles of six, eight and ten inch tile and metal drain pipe have been laid. The remarkably heavy rains in June and July created several problems for the engineering staff, which is working under the direction of Major Howard F. Wehrle, of Kansas City, Mo. He is a structural engineer who made a reputation during the war when, as a flying officer in the army air forces, he planned or built several of the more important military airdromes. Aside from his own business since the war, he has constructed many municipal and private flying fields in the Middle West and has also managed some of the principal air meets. It was that experience which led the Sesqui-Centennial Aviation Committee to appoint him managing director of the National Air Races.

Spectators to Have Fine View of Finish

A tall pylon has been erected on the field. It forms one point of the triangular race courses, two of which extend from Model Farms—a twelve mile course reaches across the Delaware and into New Jersey, a five mile course extends westward from Model Farms. The planes as they are hurled through space at record-breaking speed will turn at the home pylon directly in front of the crowds.

One hundred acres of the tract have been prepared for a motor parking area, and a concourse along which the spectators will make their way to the reserved seats and boxes in the stands.

Motors will enter the grounds from Penrose Avenue over a private road owned by the city. At the northern side of the field a parking space for planes, fuel tanks and rest houses for the pilots and mechanics have been established. A tent city has been set up to shelter the fliers, service squads and other attendants, who must live on the grounds during the meet in order to prepare for each day's varied programme.

Civilian and Service Fliers to Take Part

Not only will nearly all civilian fliers and aircraft owners participate in the races and air circus but a large part of the government forces will be on hand. The army and navy aviation branches will have on Model Farms Field sufficient personnel and equipment to darken the sky above the central part of the city. The civilian entrants are bringing to Philadelphia, for the first time, all their new types of aircraft and accessories, some of which represent recent inventions not yet announced publicly.

"On to the Sesqui" Race

The "On to the Sesqui" race, the opening event, permits the entrants to start at any time after August 24, from any part of the country and cover any distance, so that they arrive at the field before midnight of September 3rd. It is a contest to demonstrate the cross-country ability of commercial aircraft; Army and Navy and U. S. Mail airplanes will therefore not be permitted to compete. It is open to any type of civilian plane.

This race is a permanent feature of the National Air Races, similar events having been on the programs of the meets at Detroit, St. Louis, and Dayton in previous years. It carries a cash prize of $4,000 and the winner will receive the Sesqui-Centennial trophy.

Other features worthy of special mention are the three races for light airplanes with engine piston displacement of 510 cubic inches or less. The first two of these races are elimination contests, each with $1,250 in prizes. Pilots who gain a place in each race may compete in the third race for $2,000 in money prizes, the winner to be the permanent possessor of the Aero Club of Pennsylvania trophy.

The race for pilots and machines of any National Guard unit carries $1,000 in cash prizes and a trophy offered by C. Townsend Ludington. It will become the permanent possession of the winner. The air transport and speed efficiency race for the Detroit News trophy, and $2,500 in cash prizes, is designed to bring together in a reasonable test all commercial planes with a speed of 80 miles an hour or more, and at least 1,000 pounds pay load capacity.

The free-for-all pursuit ship race is open to military or naval planes of that type, owned by any government and piloted by service men. A trophy is offered the winner by the Rotary Club of Kansas City, Mo., and will become his property permanently. Individual trophies will be awarded to the first four pilots finishing the race. Similar trophy awards will be made to the pilots winning first, second, third, and fourth places in the John L. Mitchell Trophy race. It is a closed event for pilots of the First Pursuit Group, U. S. Army Air Service.

Many Trophies for Fliers

There are two relay races for civilians, each carrying prizes totalling $1,000, the winner of the first to be awarded a trophy given by B. B. T. Corporation of America and the winner of the second to receive the "Benjamin Franklin" Trophy offered by Joseph A. Steinmetz, of Philadelphia.

Among the other trophies are the "Independence Hall" trophy in the free-for-all race for two, three and four-place airplanes, with additional cash prizes totalling $2,500; the "Betsy Ross" trophy; and the "Aero Digest" trophy in the speed and efficiency race for light planes. This latter will also pay $2,000 in cash prizes. Others are the "Valley Forge" trophy to the winner of a special precision landing contest; the "Liberty Bell" trophy to the winner of the race for large capacity military airplanes, with individual trophies for the first four to finish; the model airplane race, with $500 in cash prizes and the Mulvihill Trophy; the sport plane race for civilians, with $1,500 in cash prizes and the "Scientific American" trophy; the civilian race for light planes, with $1,500 in prizes and the "Dayton Daily News" trophy; the light commercial speed and efficiency race, with $2,500 in cash prizes and the "Aviation Town and Country Club of Detroit" trophy; the race for observation type two-place military planes with the "Liberty Engine Builders" trophy and individual trophies for the first four to finish.

For the first time the national air meet will not be limited to daytime, for there will be night shows as well. The flying field will be brilliantly lighted. Gigantic aerial beacons and floodlights will turn night into day. Special thrilling aerial circus events will vary the race program. In addition to the races, there will be civilian flying exhibitions, equipment tests, stunts and comedy, parachute jumping, aerial radio tests, air transport and aerial advertising.

Army and Navy pilots will give demonstrations, both day and night, of aerial maneuvers required in war operations. In many instances, these will be under conditions that would exist in modern warfare. There will be air raids, aerial bombardment and combat, aerial defense, anti-aircraft tests and other sensational performances by famous pilots known for their daring. There will not be a single dull interval for the spectators.

Conservation of Power in Industrial Plants

Discussed at a Meeting of

The Engineers Club of Philadelphia

February 16, 1926

Presiding Officer—Afternoon Session

Dr. Robert A. Fernald, Director, Mechanical Engineering Department, University of Pennsylvania

(*Continued from page 194 of the July issue*)

Heat Insulation

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THE development of heat insulation during the past 40 years has perhaps been as phenomenal as the development of the automobile. Tests conducted by Chas. Emery in 1881 and reported before the A. S. M. E. show that many crude coverings were in use at that time. One very popular covering consisted of 4 parts of coal ashes, 1 part plaster of paris, 1 part sour flour and a small proportion of hair to act as a binder. The covering was compounded by wetting the ashes with water, putting in the hair and mixing to a mortar, the plaster and flour were then mixed together, this mixture was then worked into the hair and ashes and the resulting composition was applied to the pipes with a trowel. The sour flour in its fermentation generated considerable gas, which caused the covering to become very porous.

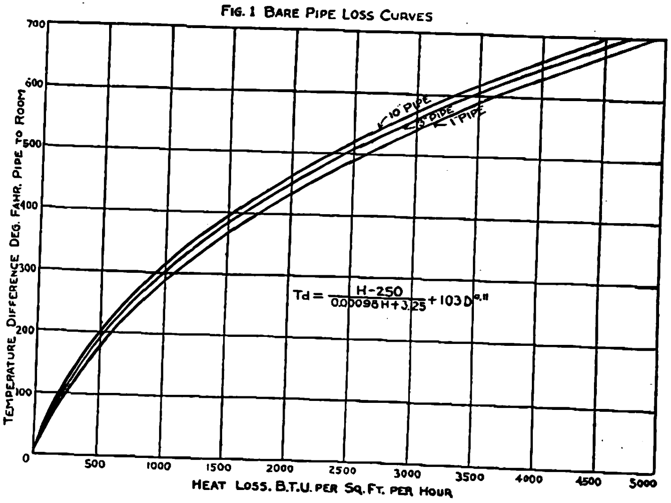
Many of the coverings used consisted mainly of organic materials which resulted in a great many disastrous fires. In fact the situation became so alarming that the Boston Manufacturers Mutual Fire Insurance Company requested Professor John M. Ordway to conduct a series of tests to determine the danger of combustion of the coverings as well as to measure their economic efficiency.

The results of about 200 tests on all types of coverings tested by Professor Ordway were reported to the A. S. M. E. in 1883 and 1884. Since that time there has been a steady development in the pipe covering art until today we have insulations which are perfectly trustworthy as far as any fire hazard is concerned and are at the same time very efficient.

However, the present tendency towards higher steam pressures and superheat, the ever increasing cost of fuel, labor, etc., makes it imperative that the greatest care be exercised in the selection of pipe covering, so as to obtain the most efficient installation for any given case. When we consider the enormous losses from bare steam lines, and the relatively low cost of insulation, it is foolish to consider using anything other than the best.

The heat losses from horizontal bare steel pipes 1″, 3″, and 10″ in diameter have been determined experimentally at Mellon Institute and are shown in Fig. 1. In these tests the 1″ pipe was heated up to a temperature of 800° F., the 3″ pipe to a temperature of 760° F., and the 10″ pipe to a temperature of 472° F.

Fig. 1 Bare Pipe Loss Curves



These curves can be expressed approximately by the empirical equations

$$H=3320\frac{77+Td-103\,D^{0.11}}{103\,D^{0.11}-Td+1020}$$

$$\text{or } Td=\frac{H-250}{0.00098H+3.25}+103\,D^{0.11}$$

in which

H=B. T. U. loss per sq. ft. of bare pipe surface.

Losses From Horizontal Bare Iron Steam Pipes

From 100 Lineal Feet of Pipe Per Month of 30 Days with Steam In Pipes 24 Hours Per Day—Coal at $4.00 Per Ton of 2000 Lbs.

Gage Press.	Hot Water			10 Lbs.			80 Lbs.			120 Lbs.			160 Lbs.			200 Lbs.			200 Lbs. and 100° F. Superheat			275 Lbs. and 250° F. Superheat		
Temp.	180° F.			239.4° F.			324.0° F.			350.0° F.			370.7° F.			387.9° F.			487.9° F.			664.3° F.		
Pipe Size	Dollars Loss	Pounds Coal	B. T. U. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B. T. U. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B. T. U. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B. T. U. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B. T. U. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B. T. U. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B. T. U. per Lineal Ft. per °F. Diff. per Hr.	Dollars Loss	Pounds Coal	B. T. U. per Lineal Ft. per °F. Diff. per Hr.
½"	1.32	526	.605	2.24	897	.670	3.92	1566	.779	4.51	1805	.815	5.25	2010	.846	5.53	2210	.875	8.60	3440	1.040	16.15	6460	1.375
1"	1.91	763	.878	3.26	1305	.973	5.72	2290	1.138	6.25	2601	1.178	7.27	2910	1.242	8.07	3230	1.280	12.56	5026	1.520	23.84	9540	2.03
1½"	2.65	1060	1.220	4.54	1818	1.357	7.98	3190	1.586	9.28	3710	1.676	10.42	4165	1.751	11.36	4550	1.804	17.94	7175	2.170	33.76	13500	2.87
2"	3.24	1297	1.491	5.36	2142	1.600	9.78	3910	1.943	11.37	4549	2.052	12.75	5100	2.145	14.00	5600	2.220	22.10	8825	2.670	42.20	16890	3.590
2½"	3.86	1545	1.778	6.65	2660	1.984	11.66	4660	2.320	13.66	5460	2.464	15.25	6100	2.564	16.70	6690	2.650	26.64	10650	3.220	50.50	20200	4.300
3"	4.56	1824	2.100	8.24	3292	2.460	13.88	5550	2.760	16.14	6450	2.910	18.04	7210	3.030	19.84	7945	3.150	31.60	12640	3.8 20	58.25	24300	5.170
3½"	5.18	2070	2.380	8.89	3554	2.655	15.82	6325	3.145	18.31	7322	3.305	20.50	8200	3.450	22.60	9040	3.580	35.90	14360	4.345	69.00	27600	5.860
4"	5.78	2305	2.650	9.87	3950	2.950	17.70	7075	3.520	25.50	8200	3.700	22.85	9145	3.842	25.15	10060	3.981	40.10	16040	4.850	72.40	30920	6.580
4½"	6.35	2540	2.920	10.94	4370	3.260	19.48	7790	3.878	22.60	9025	4.075	25.30	10120	4.250	27.75	11100	4.400	44.05	17620	5.326	85.60	34240	7.286
5"	6.95	2780	3.200	11.97	4790	3.575	21.25	8500	4.232	24.62	9850	4.450	27.60	11050	4.650	30.40	12140	4.805	49.35	19740	5.960	94.50	37800	8.050
6"	8.20	3280	3.775	14.21	5680	4.240	25.30	10110	5.024	29.30	11720	5.295	32.80	13120	5.522	36.00	14420	5.715	57.50	23000	6.955	112.50	45000	9.580
7"	9.40	3760	4.325	16.18	6470	4.826	29.10	11640	5.782	33.70	13480	6.090	37.60	15040	6.324	41.60	16650	6.560	66.25	26500	8.010	129.00	51550	10.97
8"	11.00	4398	5.050	18.25	7300	5.450	32.60	13030	6.455	37.65	15050	6.840	42.40	16940	7.125	46.05	18420	7.300	74.75	29900	9.050	146.20	58500	12.44
9"	11.62	4650	5.350	20.35	8130	6.070	36.25	14500	7.210	42.10	16840	7.600	47.22	18900	7.950	51.98	20790	8.230	83.50	33400	10.10	162.60	65050	13.84
10"	12.68	5065	5.925	22.05	8820	6.584	40.20	16100	8.010	46.70	18690	8.440	52.30	20910	8.805	57.75	23100	9.150	97.50	39000	11.18	180.00	72000	15.30
12"	15.00	6000	6.995	26.44	10580	7.890	47.40	18950	9.425	55.40	22120	10.00	61.76	24700	10.40	70.00	28010	11.14	109.30	43700	13.22	213.50	85500	18.18
14"	16.60	6635	7.625	28.90	11560	8.620	52.00	20800	10.34	60.50	24200	10.92	67.50	27000	11.36	74.10	29650	11.76	119.40	47740	14.43	233.00	93300	19.95
16"	18.82	7525	8.650	32.80	13120	9.790	58.76	23500	11.70	68.40	27320	12.34	76.10	30410	12.80	84.25	33700	13.35	135.00	54000	16.34	265.00	106000	22.55
18"	21.00	8400	9.650	36.10	14460	10.80	65.40	26150	13.00	76.50	30570	13.80	85.50	34200	14.38	93.75	37500	14.87	151.20	60500	18.30	297.50	119000	25.30

In these tables coal has been figured at $4.00 per ton of 2000 lbs. 13,000 B. T. U. per lb. of coal. Labor, boiler room expense, etc., taken at $1.00 per ton making total value of coal fired at $5.00 per ton. Boiler efficiency taken at 70 per cent, air temp. 70°F. Experimental data obtained at the Mellon Institute.

TABLE I

D=outer diameter of pipe in inches.

Td=temp. difference between pipe surface and room °F.

In Table I, these tests have been calculated to Dollars, and Pounds of coal, loss for 100 lineal feet of pipe per month. Coal has been figured at $4.00 per ton of 2,000 lbs.—13,000 B. T. U. per lb. of coal; labor, boiler room expense, etc., taken at $1.00 per ton, making total value of coal fired at $5.00 per ton. Boiler efficiency taken at 70%, air temperature 70° F. An inspection of the table shows that the loss varies from $1.32 for ½" pipe at 180° F. to $297.50 for 18" pipe at 275 lbs. pressure and 250° F. superheat with total temperature of 664°, or 526 lbs. of coal for the ½" pipe and 119,000 lbs. of coal for the 18" pipe under similar conditions.

Table II shows the efficiencies, heat savings and unit heat losses which can be obtained from a 3" thickness of good heat insulation. The savings are in B. T. U. per lineal foot of pipe per hour, the unit losses are in B. T. U. per sq. ft. of pipe surface per hr. per deg. F. temp. diff. The efficiency varies from 85.8% for ½" pipe at 100° temp. diff. to 96.2% for 18" pipe at 500° temp. diff. The saving varies from 51 B. T. U. for ½" pipe at 100° temp. diff. to 10,323 B. T. U. for 18" pipe at 500° temp. diff.

In Table III the time required to repay the original cost of the covering and the savings per year are shown for temperatures of 500° to 600° F.

There are many instances where the proper insulation of exposed or underinsulated surfaces would repay the original cost many times over in one year; for example, exposed fittings, under insulated steam lines, boilers, ovens and temporary heating appliances used in chemical and plant laboratories. The fact that pipes are covered does not end the possibility of heat losses. It is the poorest economy to use a minimum thickness of covering on high-pressure lines and apparatus when the use of a thicker covering will not only result in greater efficiency but will quickly pay for itself in the extra heat saved. The length of time required to repay the original cost of the investment depends of course on the cost of the heat that would otherwise be lost and upon the cost of the covering

3-inch Thick

Efficiencies, Heat Savings and Unit Heat Losses

Savings are in B. T. U. per lineal foot of pipe per hour.

Unit losses are in B. T. U. per square foot of pipe surface per hour per °F. temperature difference between pipe and surrounding air.

Pipe Size		Temperature Diff. °F. Between Pipe and Surrounding Air.								
		100° F.	150° F.	200° F.	250° F.	300° F.	350° F.	400° F.	450° F.	500° F.
½"	% Eff.........	85.8%	86.4%	86.9%	87.5%	88.2%	88.8%	89.2%	89.8%	90.3%
	Saving.........	51	84	123	169	223	287	359	442	537
	Unit Loss......	0.384	0.402	0.419	0.437	0.454	0.472	0.489	0.507	0.524
¾"	% Eff.........	87.0%	87.5%	88.1%	88.7%	89.3%	89.9%	90.4%	90.9%	91.3%
	Saving.........	61	101	149	205	271	349	439	541	659
	Unit Loss......	0.335	0.350	0.365	0.380	0.395	0.410	0.425	0.440	0.455
1"	% Eff.........	88.0%	88.5%	89.1%	89.7%	90.2%	90.7%	91.2%	91.7%	92.1%
	Saving.........	76	125	184	254	335	432	545	672	819
	Unit Loss......	0.300	0.313	0.327	0.340	0.354	0.367	0.381	0.394	0.408
1¼"	% Eff.........	89.3%	89.7%	90.2%	90.7%	91.2%	91.6%	92.1%	92.5%	92.9%
	Saving.........	95	157	231	318	421	542	685	845	1027
	Unit Loss......	0.263	0.275	0.288	0.300	0.313	0.325	0.338	0.350	0.363
1½"	% Eff.........	89.8%	90.2%	90.7%	91.2%	91.6%	92.1%	92.5%	92.9%	93.3%
	Saving.........	108	178	262	362	479	617	779	959	1167
	Unit Loss......	0.247	0.258	0.270	0.281	0.293	0.304	0.316	0.327	0.339
2"	% Eff.........	90.5%	90.9%	91.4%	91.9%	92.3%	92.7%	93.1%	93.5%	93.9%
	Saving.........	132	219	324	449	594	765	964	1194	1454
	Unit Loss......	0.224	0.234	0.244	0.254	0.265	0.275	0.285	0.295	0.305
2½"	% Eff.........	91.0%	91.4%	91.9%	92.1%	92.8%	93.2%	93.6%	94.0%	94.3%
	Saving.........	157	260	385	532	706	911	1153	1430	1743
	Unit Loss......	0.206	0.216	0.225	0.234	0.244	0.253	0.262	0.271	0.281
3"	% Eff.........	91.6%	91.9%	92.4%	92.8%	93.2%	93.5%	94.0%	94.3%	94.6%
	Saving.........	189	312	462	638	848	1096	1388	1723	2103
	Unit Loss......	0.190	0.199	0.208	0.217	0.226	0.234	0.243	0.252	0.261
3½"	% Eff.........	92.0%	92.3%	92.8%	93.2%	93.5%	93.9%	94.2%	94.6%	94.9%
	Saving.........	214	352	523	724	961	1242	1571	1952	2384
	Unit Loss......	0.178	0.186	0.195	0.203	0.212	0.221	0.230	0.238	0.247
4"	% Eff.........	92.1%	92.5%	92.9%	93.3%	93.7%	94.1%	94.4%	94.7%	95.0%
	Saving.........	238	393	583	809	1074	1390	1758	2186	2672
	Unit Loss......	0.173	0.181	0.189	0.197	0.205	0.213	0.222	0.230	0.238
4½"	% Eff.........	92.4%	92.7%	93.1%	93.5%	93.9%	94.2%	94.5%	94.9%	95.1%
	Saving.........	263	434	642	895	1188	1539	1943	2417	2955
	Unit Loss......	0.166	0.174	0.182	0.190	0.198	0.206	0.214	0.222	0.230
5"	% Eff.........	92.5%	92.8%	93.2%	93.6%	94.0%	94.4%	94.7%	95.0%	95.2%
	Saving.........	290	479	709	989	1315	1705	2174	2680	3270
	Unit Loss......	0.162	0.169	0.177	0.185	0.192	0.199	0.207	0.215	0.223
6"	% Eff.........	92.7%	93.1%	93.5%	93.9%	94.2%	94.6%	94.9%	95.2%	95.5%
	Saving.........	343	567	841	1174	1561	2023	2565	3184	3888
	Unit Loss......	0.155	0.162	0.169	0.176	0.183	0.190	0.197	0.204	0.211
7"	% Eff.........	93.0%	93.4%	93.7%	94.1%	94.5%	94.8%	95.1%	95.4%	95.7%
	Saving.........	392	650	963	1346	1802	2323	2945	3659	4568
	Unit Loss......	0.148	0.154	0.163	0.169	0.176	0.182	0.189	0.195	0.202
8"	% Eff.........	93.1%	93.5%	93.9%	94.3%	94.6%	94.9%	95.2%	95.5%	95.8%
	Saving.........	440	733	1087	1514	2016	2623	3327	4133	5049
	Unit Loss......	0.144	0.150	0.157	0.163	0.170	0.177	0.184	0.190	0.197
9"	% Eff.........	93.3%	93.7%	94.0%	94.4%	94.7%	95.0%	95.4%	95.6%	95.8%
	Saving.........	490	816	1211	1686	2247	2923	3708	4622	5626
	Unit Loss......	0.140	0.146	0.152	0.159	0.166	0.173	0.179	0.186	0.194
10"	% Eff.........	93.4%	93.8%	94.1%	94.5%	94.8%	95.1%	95.4%	95.6%	95.9%
	Saving.........	545	907	1346	1876	2499	3255	4128	5131	6269
	Unit Loss......	0.137	0.143	0.150	0.156	0.163	0.169	0.176	0.182	0.189
12"	% Eff.........	93.5%	93.9%	94.2%	94.6%	94.9%	95.3%	95.5%	95.8%	96.1%
	Saving.........	641	1069	1589	2215	2953	3848	4870	6056	7405
	Unit Loss......	0.133	0.139	0.145	0.151	0.157	0.163	0.170	0.176	0.182
14"	% Eff.........	93.6%	93.9%	94.3%	94.6%	95.0%	95.3%	95.6%	95.8%	96.1%
	Saving.........	699	1161	1722	2409	3214	4191	5307	6603	8077
	Unit Loss......	0.131	0.137	0.143	0.149	0.155	0.161	0.168	0.174	0.180
16"	% Eff.........	93.7%	94.0%	94.4%	94.7%	95.0%	95.4%	95.6%	95.9%	96.1%
	Saving.........	796	1315	1958	2734	3650	4762	6035	7513	9192
	Unit Loss......	0.128	0.134	0.140	0.146	0.152	0.158	0.164	0.170	0.176
18"	% Eff.........	93.8%	94.1%	94.5%	94.8%	95.1%	95.5%	95.8%	96.0%	96.2%
	Saving.........	894	1479	2202	3075	4107	5342	6775	8400	10323
	Unit Loss......	0.125	0.130	0.136	0.142	0.148	0.154	0.159	0.165	0.173
Flat	% Eff.........	94.4%	94.7%	95.0%	95.3%	95.6%	95.9%	96.2%	96.4%	96.6%
	Saving.........	182	300	447	622	832	1081	1369	1695	2087
	Unit Loss......	0.107	0.112	0.117	0.122	0.127	0.132	0.137	0.142	0.147

All data from Mellon Institute. University of Pittsburgh tests.

TABLE II

Time Required to Repay Original Cost and Savings Per Year

Pipe Temperature °F.		500					550					600				
	Fuel Cost	.15	.20	.25	.30	.35	.15	.20	.25	.30	.35	.15	.20	.25	.80	.35
2" Pipe	Material	2"th. Mg.					2"th. Mg.					1"th. H-T. 1½"th. Mg.				
Covering & application ist	Months Required	8.50	6.39	5.10	4.24	3.63	6.9	5.2	4.2	3.5	2.9	7.7	5.7	4.6	3.8	3.3
	Saving per yr.	1.28	1.75	2.22	2.70	3.17	1.60	2.18	2.76	3.14	3.92	1.93	2.63	3.34	4.03	4.74
Covering & application list—20%	Months Required	6.80	5.10	4.08	3.47	2.90	5.6	4.2	3.3	2.8	2.4	6.1	4.6	3.7	3.1	2.9
	Saving per yr.	1.31	1.78	2.25	2.73	3.20	1.63	2.21	2.79	3.37	3.95	1.99	2.69	3.40	4.09	4.80
4" Pipe	Material	D. S. Mg.					D. S. Mg.					1"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	6.5	4.8	3.9	3.2	2.8	5.3	4.0	3.2	2.6	2.3	7.1	5.3	4.2	3.7	3.1
	Saving per yr.	2.42	3.29	4.15	5.02	5.89	3.01	4.07	5.14	6.20	7.27	3.21	4.91	6.31	7.51	8.81
Covering & application list—20%	Months Required	5.2	3.9	3.1	2.6	2.20	4.2	3.2	2.5	2.1	1.8	5.7	4.2	3.4	2.80	2.4
	Saving per yr.	2.47	3.34	4.20	5.07	5.94	3.06	4.12	5.19	6.25	7.32	3.67	4.97	6.37	7.57	8.87
6" Pipe	Material	3"th. Mg.					3"th. Mg.					1"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	8.5	6.3	5.1	4.2	3.5	6.9	5.2	4.1	3.4	2.9	5.9	4.4	3.5	2.9	2.5
	Saving per yr.	3.48	4.76	6.05	7.32	8.60	4.35	5.93	7.50	9.07	10.65	5.34	7.24	9.14	11.04	12.94
Covering & application list—20%	Months Required	6.6	5.1	4.0	3.4	2.9	5.5	4.1	3.3	2.7	2.4	4.7	3.5	2.8	2.4	2.0
	Saving per yr.	3.55	4.83	6.12	7.39	8.69	4.42	6.00	7.57	9.14	10.72	5.41	7.31	9.21	11.11	12.01
8" Pipe	Material	3"th. Mg.					3"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	7.6	5.7	4.6	3.8	3.3	6.2	4.6	3.7	2.1	2.7	6.3	4.7	3.8	3.1	2.7
	Saving per yr.	4.55	6.21	7.86	9.52	11.17	5.70	7.74	9.77	11.80	13.84	6.94	9.42	11.90	14.37	16.86
Covering & application list—20%	Months Required	6.1	4.6	3.7	3.8	2.6	5.0	3.7	3.0	2.5	2.1	5.0	3.8	3.0	2.5	2.2
	Saving per yr.	4.63	6.29	7.9	9.60	11.25	5.78	7.82	9.85	11.88	13.92	7.03	9.51	11.99	14.46	16.95
10" Pipe	Material	3"th. Mg.					3"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	7.1	5.4	4.2	3.5	3.0	5.8	4.2	3.5	2.9	2.5	6.0	4.6	3.6	3.0	2.6
	Saving per yr.	5.72	7.79	9.85	11.93	13.99	7.13	9.65	12.19	14.73	17.26	8.66	11.72	14.81	17.90	21.00
Covering & application list—20%	Months Required	5.6	4.2	3.4	2.8	2.4	4.6	3.5	2.8	2.3	2.0	4.8	3.6	2.9	2.4	2.1
	Saving per yr.	5.82	7.88	9.94	12.02	14.08	7.22	9.74	12.28	14.82	17.35	8.77	11.84	14.93	18.02	21.12
12" Pipe	Material	3½"th. Mg.					3½"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	7.8	5.9	4.7	3.9	3.4	6.4	4.7	3.8	3.2	2.7	5.5	4.1	3.3	2.7	2.4
	Saving per yr.	6.71	9.15	11.59	14.06	15.49	8.42	11.42	14.43	17.46	20.47	10.28	13.93	17.56	21.25	24.85
Covering & application list—20%	Months Required	6.3	4.7	3.8	3.1	2.7	5.1	3.8	3.1	2.5	2.2	4.4	3.3	2.6	2.2	1.9
	Saving per yr.	6.84	9.28	11.72	14.19	15.62	8.55	11.55	14.56	17.59	20.60	10.41	14.06	17.69	21.38	24.93
14" Pipe	Material	3½"th. Mg.					3½"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	8.2	6.1	4.9	4.1	3.5	6.6	5.0	4.0	3.8	2.8	5.4	4.1	3.2	2.7	2.3
	Saving per yr.	7.29	9.97	12.64	15.29	17.99	9.14	12.41	15.69	18.99	22.29	11.58	15.68	19.78	23.88	27.98
Covering & application list—20%	Months Required	6.5	4.9	3.9	3.3	2.8	5.3	4.0	3.2	2.7	2.3	4.3	3.2	2.6	2.2	1.9
	Saving per yr.	7.43	10.11	12.78	15.43	18.13	9.28	12.55	15.83	19.13	23.43	11.72	15.82	19.92	24.02	27.12
16" Pipe	Material	3½"th. Mg.					3½"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	8.8	6.6	5.3	4.4	3.8	6.5	4.9	3.9	3.3	2.8	5.4	4.1	3.3	2.7	2.3
	Saving per yr.	7.52	10.30	13.10	15.85	19.60	10.40	14.15	17.90	21.60	25.35	12.75	17.28	21.80	26.30	30.84
Covering & application list—20%	Months Required	7.0	5.3	4.2	3.5	3.0	5.2	3.9	3.1	2.6	2.2	4.4	3.3	2.6	2.2	1.9
	Saving per yr.	7.69	10.47	13.27	16.02	19.77	10.57	14.32	18.07	21.77	25.52	12.92	17.44	21.96	26.46	31.00
18" Pipe	Material	3½"th. Mg.					3½"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Motnhs Required	7.8	5.8	4.7	3.9	3.3	6.3	4.7	3.8	3.2	2.7	5.3	4.0	3.2	2.6	2.3
	Saving per yr.	9.34	12.76	16.16	19.56	22.96	11.72	15.90	20.10	24.30	28.50	14.39	19.49	24.57	29.65	34.73
Covering & application list—20%	Months Required	6.2	4.7	3.7	3.1	2.7	5.0	3.8	3.0	2.5	2.2	4.2	3.2	2.5	2.1	1.8
	Saving per yr.	9.51	12.93	16.32	19.72	23.12	11.89	16.07	20.27	24.47	28.57	14.56	19.66	24.74	29.82	34.90
Flat Surface	Material	4 'th. Mg.					4"th. Mg.					1½"th. H-T. 2½"th. Mg.				
Covering & application list	Months Required	7.0	5.2	4.2	3.5	3.0	5.7	4.2	3.4	2.8	2.4	4.7	3.5	2.8	2.3	2.0
	Saving per yr.	1.91	2.60	3.28	3.98	4.66	2.38	3.23	4.08	4.94	5.78	2.92	3.95	4.98	6.00	7.03
Covering & application list—20%	Months Required	5.6	4.2	3.3	2.8	2.4	4.5	3.4	2.7	2.3	1.9	3.7	2.8	2.2	1.9	1.6
	Saving per yr.	1.95	2.64	3.33	4.02	4.70	2.42	3.27	4.12	4.98	5.82	2.96	3.99	5.02	6.04	6.07

TABLE III

as applied, together with the annual fixed charges.

The cost of heat varies considerably in various plants and localities, so that calculations based on one cost of steam would obviously be applicable only to that particular case. Some of the factors that influence the cost of steam are cost of fuel, heat content of the fuel, efficiency of the installation, method of firing, load factor, charges against the investment in boiler plant and operating charges.

Some of the factors that influence the cost of the insulation as applied are initial cost of material, labor rate per hour, amount of cement work compared with straight pipe and blocks, number of fittings and bends compared with straight pipe, accessibility of pipes, painting, weight of canvas and application of canvas (pasted or stitched).

Before compiling the tables herewith, the author corresponded with ten representative firms of consulting engineers in the power-plant field in regard to the cost of steam and specifications for thickness of material used as standard practice in insulating superheated steam lines. The cost of steam for the firms corresponded with was found to vary from 14 to 50 cents per 1,000,000 B. T. U. The cost and application of the covering varies for different plants, as mentioned above. However, one large pipe-covering contractor finds for his work that in general the actual cost of covering for superheated steam lines to the central station, in place and finished, is approximately the list net price of the covering.

In order to form a definite comparison, the author has chosen for the cost of covering as applied, list net, and the cost of fuel at the boiler nozzle of 15, 20, 25, 30 and 35 cents per 1,000,000 B. T. U. There are many cases where the actual cost and application of pipe covering will exceed the list price of the covering and there are also many cases where the cost of steam will greatly exceed 35 cents per 1,000,000 B. T. U.

In order to make intelligent use of the tables shown it will be necessary for the engineer first to determine the cost of steam for his particular case and the approximate cost of the covering in terms of the list price. If these costs do not correspond with those given in the tables, it will be necessary to interpolate. The tables show the time required to repay the original cost of the covering and its application, and also the savings in dollars per year per linear foot of pipe and per square foot of flat surface, for various temperatures and pipe sizes. In computing the tables High Temperature insulation and 85 per cent magnesia have been used as the insulation. The most economical thickness has been used for the average of the steam costs assumed and the thickness of the High Temperature insulation as the inner layer has been chosen so that the temperature at the inner surface of the magnesia next to the High Temperature insulation will not exceed 550 deg. F.

In Table III for a 10″ pipe covered with 3″ thickness of 85% magnesia with steam at $0.25 per 1,000,000 B. T. U. and a pipe temperature of 500° F., we find that it will take 4.2 months to pay for the covering when the cost of the covering and application is taken at list price. When the cost and application is taken at list—20%, it will take only 3.4 months to repay the cost of the installation. The savings per year in the first case amount to $9.85 per lineal foot of pipe.

Table IV gives similar results for pipe temperatures of 800 to 900° F. Here we find for a 10″ pipe covered with 1½″ thickness of High Temperature insulation and 2″ thickness of 85% Magnesia, with a steam cost of $0.25 per 1,000,000 B. T. U. and a pipe temperature of 900° F., that it will take 1.5 months to repay the cost of the installation with the cost of the covering and application at list price. The savings per year for the same conditions amount to $37.90 per lineal foot of pipe.

The engineer is often confronted with the question, what thickness of insulation should be used for a specific case? While this is a very important query, the answer is not readily obtainable, as considerable calculation is necessary to solve this economic problem. There are several methods by which the desired results can be obtained and, since several papers have been presented recently on the determination of economic thickness, it might be of interest to describe the method used at Mellon Institute.

Since the result desired is the maximum net saving of money for any given condition, it is necessary to know the total yearly operating expenses of the covered line. Having obtained these expenses for various thicknesses of covering for a given pipe size and a given fuel cost at a specified temperature, obviously the most economical thickness of covering to use would be that thickness that gave the lowest total yearly operating expenses.

The total yearly operating expenses consist of the annual cost of the heat lost through the covered line and the annual fixed charges on the cost of the covering itself.

The annual operating expenses are determined by calculating the loss through the covernig on a yearly basis for various thicknesses of covering and multiplying this loss by the cost of the fuel per 1,000,000 B. T. U. The operating expenses for a covering on a ½″ pipe are shown in Fig. 2.

These curves are for temperature differences of 100°, 200° and 300° with steam at 20c per 1,000,000 B. T. U.

The annual fixed charges are determined from the first cost of the covering, the cost of the application of the covering, and the annual interest and depreciation charges. These charges should be figured in terms of the list price of the covering if possible.

Time Required to Repay Original Cost and Savings per Year

Pipe Temperature °F.		800					850					900				
	Fuel Cost	.15	.20	.25	.30	.35	.15	.20	.25	.30	.35	.15	.20	.25	.30	.35
2" Pipe	Material	1"th. H-T. 2"th. Mg.					1"th. H-T. 2"th. Mg.					1"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	5.1	3.8	3.1	2.6	2.2	4.5	3.4	2.7	2.2	1.9	4.1	3.0	2.4	2.0	1.7
	Saving per yr.	3.78	5.13	6.47	7.79	9.13	4.35	5.88	7.39	8.93	10.44	4.85	6.54	8.23	9.93	11.62
Covering & application list—20%	Months Required	4.1	3.1	2.5	2.1	1.8	3.6	2.7	2.2	1.8	1.5	3.3	2.4	2.0	1.6	1.4
	Saving per yr.	3.82	5.17	6.51	7.83	9.17	4.39	5.92	7.43	8.97	10.48	4.89	6.58	8.27	9.97	11.66
4" Pipe	Material	1½"th. H-T. 2"th. Mg.					1½"th. H-T. 2"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	4.4	3.3	2.6	2.2	1.9	3.8	2.9	2.3	1.9	1.6	3.4	2.5	2.0	1.7	1.5
	Saving per yr.	7.13	9.62	12.11	14.61	17.11	8.22	11.08	13.95	16.80	19.65	9.31	12.53	15.75	18.97	22.20
Covering & application list—20%	Months Required	3.5	2.6	2.1	1.8	1.5	3.1	2.3	1.8	1.5	1.3	2.7	2.0	1.6	1.4	1.2
	Saving per yr.	7.20	9.69	12.18	14.68	17.18	8.29	11.15	14.02	16.87	19.72	9.38	12.61	15.83	19.04	22.27
6" Pipe	Material	1½"th. H-T. 2"th. Mg.					1½"th. H-T. 2"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	3.6	2.7	2.2	1.8	1.6	3.2	2.4	1.9	1.6	1.4	2.8	2.1	1.7	1.4	1.2
	Saving per yr.	10.47	14.09	17.72	20.37	24.97	12.10	16.28	20.47	24.65	28.80	13.79	18.55	23.27	28.00	32.77
Covering & application list—20%	Months Required	2.9	2.2	1.7	1.5	1.2	2.5	1.9	1.5	1.3	1.1	2.2	1.7	1.3	1.1	1.0
	Saving per yr.	10.57	14.19	17.82	20.47	25.07	12.20	16.38	20.57	24.75	28.90	13.89	18.65	23.37	28.10	32.87
8" Pipe	Material	1½"th. H-T. 2"th. Mg.					1½"th. H-T. 2"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	3.0	2.2	1.8	1.5	1.3	2.6	1.9	1.5	1.3	1.1	2.3	1.7	1.4	1.1	1.0
	Saving per yr.	13.69	18.44	23.15	27.89	32.64	15.78	21.19	26.59	32.09	37.49	18.05	24.19	30.39	36.59	42.79
Covering & application list—20%	Months Required	2.6	2.0	1.6	1.3	1.1	2.3	1.7	1.4	1.1	1.0	2.0	1.5	1.2	1.0	0.9
	Saving per yr.	13.79	18.54	23.25	27.99	32.74	15.88	21.29	26.69	32.19	37.59	18.15	24.29	30.49	36.69	42.89
10" Pipe	Material	1½"th. H-T. 2"th. Mg.					1½"th. H-T. 2"th. Mg.					1½"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	3.2	2.4	1.9	1.6	1.4	2.8	2.1	1.7	1.4	1.2	2.4	1.8	1.5	1.2	1.0
	Saving per yr.	17.05	22.40	28.80	34.70	40.50	19.60	26.35	33.10	39.85	46.60	22.50	30.20	37.90	45.60	53.30
Covering & application list—20%	Months Required	2.5	1.9	1.5	1.3	1.1	2.2	1.6	1.3	1.1	0.9	1.9	1.4	1.2	1.0	0.8
	Saving per yr.	17.17	23.02	28.92	34.82	40.62	19.72	26.47	33.22	39.97	46.72	22.62	30.32	38.02	45.72	53.42
12" Pipe	Material	2"th. H-T. 2"th. Mg.					2"th. H-T. 2"th. Mg.					2"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	3.5	2.6	2.1	1.8	1.5	3.1	2.3	1.8	1.5	1.3	2.7	2.0	1.6	1.4	1.2
	Saving per yr.	20.10	27.10	33.10	40.10	37.10	23.20	31.20	39.20	47.20	55.20	26.60	35.70	44.80	54.05	63.20
Covering & application list—20%	Months Required	2.8	2.1	1.7	1.4	1.2	2.5	1.8	1.5	1.2	1.1	2.2	1.5	1.3	1.1	0.9
	Saving per yr.	20.26	27.26	33.26	40.26	47.26	23.36	31.36	39.36	47.36	55.36	26.76	35.86	44.96	54.21	63.36
14" Pipe	Material	2"th. H-T. 2"th. Mg.					2"th. H-T. 2"th. Mg.					2"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	3.4	2.6	2.0	1.7	1.5	3.0	2.3	1.8	1.5	1.3	2.6	2.0	1.6	1.3	1.1
	Saving per yr.	22.04	29.64	37.44	44.94	52.64	25.44	34.24	42.46	57.74	60.54	29.16	39.16	49.16	59.16	69.16
Covering & application list—20%	Months Required	2.8	2.1	1.7	1.4	1.2	2.4	1.8	1.4	1.2	1.0	2.1	1.6	1.3	1.1	0.9
	Saving per yr.	22.21	29.81	37.51	45.11	52.81	25.61	34.41	43.13	51.91	60.71	29.33	39.33	49.33	59.33	69.33
16" Pipe	Material	2"th. H-T. 2"th. Mg.					2"th. H-T. 2"th. Mg.					2"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	3.4	2.5	2.0	1.7	1.4	2.9	2.2	1.8	1.5	1.3	2.6	1.9	1.5	1.3	1.1
	Saving per yr.	25.15	33.85	42.55	51.15	59.95	28.95	38.95	48.95	58.85	68.85	33.15	44.55	55.95	67.25	78.65
Covering & application list—20%	Months Required	2.7	2.0	1.6	1.3	1.2	2.3	1.8	1.4	1.2	1.0	2.0	1.5	1.2	1.0	0.9
	Saving per yr.	25.34	34.04	42.74	51.34	60.04	29.14	39.14	49.14	59.04	69.04	33.34	44.74	56.14	67.44	78.84
18" Pipe	Material	2"th. H-T. 2"th. Mg.					2"th. H-T. 2"th. Mg.					2"th. H-T. 2"th. Mg.				
Covering & application list	Months Required	3.2	2.4	1.9	1.6	1.4	2.8	2.1	1.7	1.4	1.2	2.5	1.8	1.5	1.2	1.1
	Saving per yr.	28.33	38.13	47.98	57.63	67.48	32.68	43.88	55.06	66.28	77.48	37.18	50.08	62.98	75.68	88.48
Covering & application list—20%	Months Required	2.6	1.9	1.5	1.3	1.1	2.2	1.7	1.3	1.1	1.0	2.0	1.5	1.2	1.0	0.8
	Saving per yr.	28.53	38.33	48.18	57.83	67.68	32.88	44.06	55.28	66.48	77.68	37.38	50.28	63.18	75.88	88.68
Flat Surface	Material	2"th. H-T. 2½"th. Mg.					2"th. H-T. 2½"th. Mg.					2"th. H-T. 2½"th. Mg.				
Covering & application list	Months Required	2.7	2.0	1.6	1.4	1.2	2.8	1.8	1.4	1.2	1.0	2.1	1.6	1.3	1.0	0.9
	Saving per yr.	5.76	7.73	9.72	11.72	13.70	6.61	8.88	11.14	13.40	15.67	7.57	10.15	12.72	15.32	17.88
Covering & application list—20%	Months Required	2.2	1.6	1.3	1.1	0.9	1.9	1.4	1.1	1.0	0.8	1.7	1.3	1.0	0.8	0.7
	Saving per yr.	5.80	7.77	9.76	11.76	13.74	6.65	8.92	11.18	13.44	15.71	7.61	10.19	12.76	15.36	17.92

TABLE IV

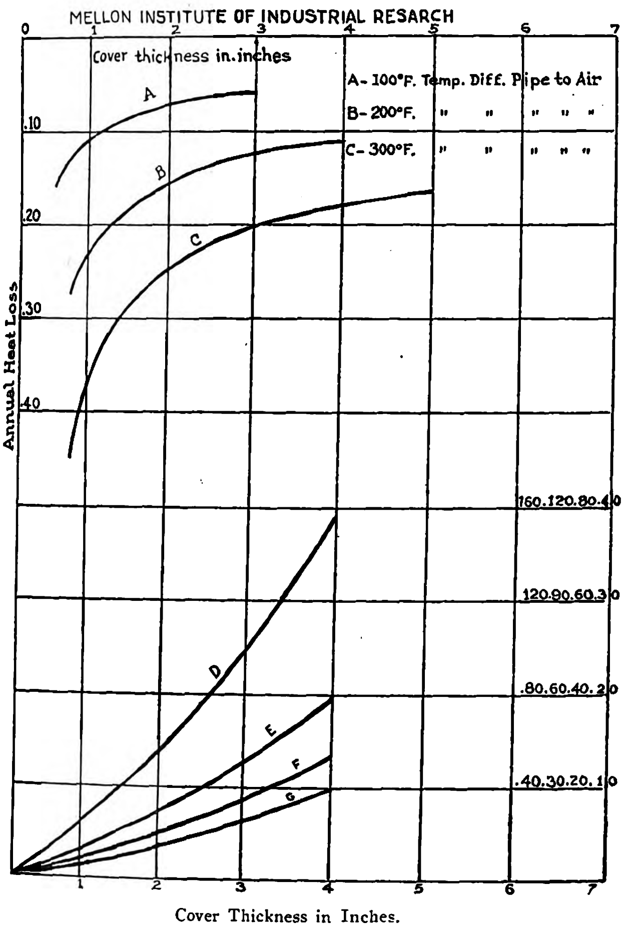


FIGURE 2. OPERATING COSTS FOR CAROCEL COVERING ON 1.5 INCH PIPE

Annual Fixed Charges

D	80c steam	Curve D
E	60c steam	Curve E
F	40c steam	Curve F
G	20c steam	Curve G

Such curves are shown in Fig. 3. The curves at the bottom of the figure are estimated on the basis of annual fixed charges of 8% of the list price of the covering. Having plotted the annual operating expenses for various thicknesses of covering for various temperature differences, with steam at 20c per 1,000,000 B. T. U., and the annual fixed charges for various thicknesses of covering, on the same sheet of paper, there are several methods by which the economic thickness can be obtained.

One method of solution would be to record the ordinate or value represented by the distance measured downward (along the 1 in. thickness line) from the upper axis to the A curve, and also to record the value represented by the distance measured upward (along the 1 in. thickness line) from the lower axis to the D curve. The sum of these two values would represent the annual cost for the 1 in. thickness.

The same process would be repeated for other thicknesses, chosen preferably at 0.1 in. intervals. Then the thickness giving the smallest loss could be selected.

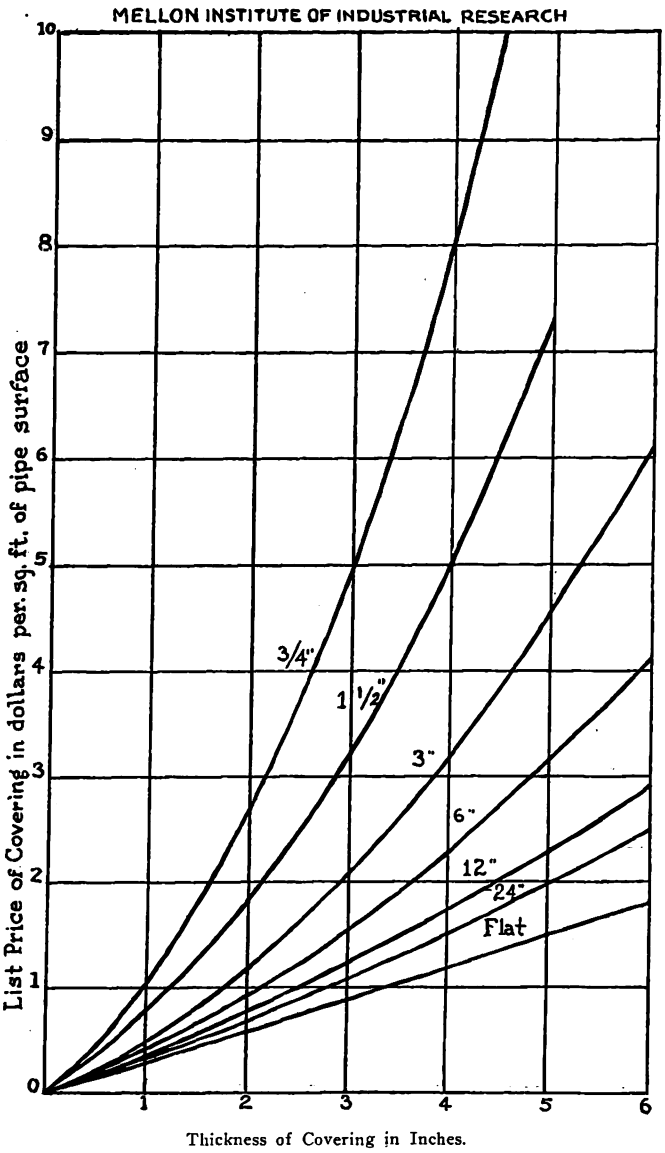


FIGURE 3. LIST PRICE OF COVERINGS

A quicker way would be to locate the thickness at which the tangent to the A curve and the tangent to the D curve were parallel. At that point the rate of change of each curve would be the same, and the total loss would be a minimum.

Moving to the right would increase the D curve more than it would decrease the A curve; moving to the left would increase the A curve more than it would decrease the D curve.

For steam at 40 cents per 1,000,000 B. T. U., it would be necessary to plot curves A, B and C with ordinates twice as great, since the same B. T. U. loss would represent twice as great a cash loss. The annual fixed charges and, therefore, the D curve would remain unchanged. The method of tangents could be used as before, and the economic thickness could be determined. That plan, however, would involve replotting curves A, B and C. A less laborious procedure would be to leave the curves A, B and C unchanged but to double the values of the ordinates; that is, each square measured downward count for twice as much cash value.

It would then be necessary to replot the D curve. The actual cash values of annual fixed charges would remain unchanged; but since the value of the ordinate scale was doubled, the D ordinates would have to be divided by two. Curve E would be the result. Thus curve E would be plotted on the same scale as curves A, B, and C, and could be used with them in the tangent method. The result would be the economic thickness with steam at 40 cents per 1,000,000 B. T. U.

For 60 cents steam, the ordinate of curves A, B and C were made of triple value, and curve D was replotted as curve F. For 80 cents steam, the ordinates of curves A, B and C were made of quadruple value, and curve D was replotted as curve G with ordinates one-fourth as great but of equal cash value with the D ordinates.

The results from the tangent method on this one curve sheet gave all the required economic thicknesses for ½" pipe. The same process was used for the other pipe sizes and for flat surfaces. The economic thickness curves for 85% magnesia for temperature differences of 100-300° F. is shown in Fig. 4.

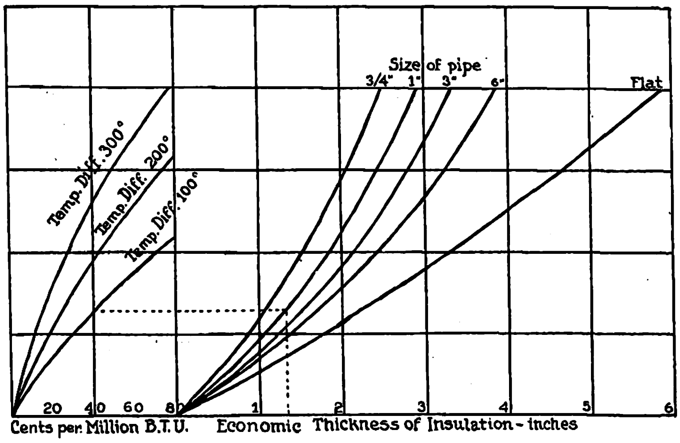


FIGURE 4. ECONOMIC THICKNESS OF MAGNESIA

It should be mentioned here that fairly wide variation in thickness of covering causes little difference in the total annual charges, so that the commercial thickness which most nearly fits the curves can be chosen with little sacrifice in economy. It should be kept in mind, however, that when in doubt a greater rather than a lesser thickness is usually chosen, as the covering generally pays for itself in a very short time.

The question will probably be asked as to how the economic thickness curves will be affected for coverings on a heating system which is in operation only a part of the year. Owing to the fact that the annual fixed charges will remain the same, while the annual operating expenses will be reduced proportionately to the reduction in time of operation, it will be found that the economic thickness can be determined by multiplying the B. T. U. actual cost by the proportion of actual monthly operation to 12 using this as the B. T. U. cost instead of the actual cost. For example if the actual cost of the heat is \$0.60 per 1,000,000 B. T. U. and the system operates 6 months of the year, the cost to use in determing the economic thickness=\$0.60x6/12=\$0.30.

In instances where the steam cost is not known, the cost per ton of coal can be calculated to cost per 1,000,000 B. T. U. by dividing the cost per ton by the B. T. U. value of the coal, multiplied by the efficiency of the boiler. An efficiency of about 50% can be assumed for domestic steam and hot water systems, and about 65% for larger building units.

Since one ton of coal contains approximately 28,000,000 B. T. U., the cost of heat for a domestic boiler operating at 50% efficiency and coal cost of \$6.00 per ton= $\frac{\$6.00}{28x.50}=\$0.43$ per 1,000,000 B. T. U.

Having discussed the economic side of heat losses from bare and covered surfaces, we will next discuss briefly some points of the manufacturing side. There are only about four raw materials which can be used in the manufacture of insulation for steam surfaces. These are asbestos, magnesia, celite or kieselguhr and slag wool.

Asbestos starts to lose strength at about 400° F., magnesia starts to calcine at about 500° F., celite starts to shrink badly at temperatures above 1600° F., and slag wool begins to disintegrate at about 1200° F.

These materials have been used singly or in combination in the manufacture of heat insulation for at least 25 years. Only recently, however, have research engineers and chemists taken an active interest in the scientific development of these materials into better and more practical insulation. For instance careful study and experimentation has shown that a mixture of a large quantity of a material which calcines at a low temperature and a comparatively small quantity of material which calcines at a high temperature can be made to bring about a chemical reaction which results in a material which calcines at a temperature only slightly below the calcination point of the high temperature material, at the same time producing a better non-conductor of heat.

The ever increasing improvements and refinements, resulting in greater efficiency in power plant practice, demand the same care and exactness in the development of suitable heat insulations. Having only a few raw materials with which to work with does not allow of any laxity in the devenopment of the products into better and more practical insulations from the standpoint of efficiency, durability, ease of handling, shipping, etc.

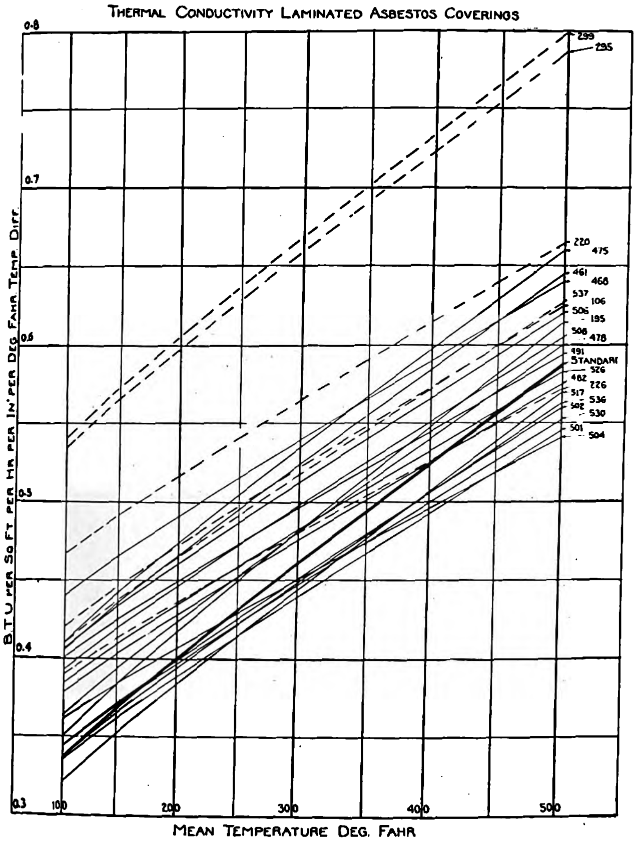


FIGURE 5

Fig. 5 shows the results of research carried out at Mellon Institute on the development of the laminated asbestos covering. These curves are the results of tests on laminated asbestos coverings in terms of B. T. U. per hr., per sq. ft., per in. thickness, per deg. F. mean temperature, which means that all the curves have been reduced to a basis of exactly the same thickness. The solid lines are the results of a few of over 100 tests on pipe coverings all of which, to the casual obscerver, would appear to be exactly the same covering. The value of careful study and logical development is very clearly seen in this diagram where the insulating value of the same material has been increased by about 20%. In explaining briefly how this improvement was obtained, it might be well to mention how the heat is transmitted through a laminated asbestos covering. Heat flows through the cover by radiation, conduction and convection. The slope of the conductivity curve gives us some indication of the relative transfer by radiation, conduction and convection. Since the radiation loss is proportional to the difference of the fourth powers of the absolute temperatures, it is to be expected that a covering in which the heat flow takes place mainly by radiation will show a very steep conductivity curve. The increase in heat loss due to internal convection currents will also tend to cause the conductivity curve to be steeper than for conduction only. Tests made by the National Physical Laboratory on external convection losses from plane surfaces show that the heat loss by natural convection is proportional to the five-fourths power of the temperature rise above the ambient temperature. While this proportion may not hold true for the convection losses within a covering, it is possible that the loss due to internal convection increases at a greater rate than the loss due to conduction.

Another important item in the transfer of heat through a laminated covering is the matter of film resistance, or the high resistance offered to the flow of heat by conduction, through the thin film adjacent to each layer of paper. A good example of film resistance is to be found in the case of the heat loss from a bare iron pipe. While the iron itself will easily transmit say 1200 B. T. U. per hour, the resistance of the thin air film at the surface of the pipe will allow a transfer of only 3 B. T. U. per hour.

Since radiation and convection take place only through voids in the covering, the loss due to these two can be controlled by controlling the size and shape of the voids in the covering.

The loss through the covering by conduction is relatively very important and required careful analysis to bring about the desired results.

A casual examination of the curves gives the impression that the curves are all parallel, but upon examining the curves closely you will note that the slopes of the curves are very different.

In closing it should be emphasized to the engineering profession that any type of laminated covering is not sufficient just because it is laminated.

Discussion

M. B. FLANDERS: Many years ago Dr. Thurston told us you could put too great a thickness of covering on the pipe, as after a certain diameter of covering was applied the path of the heat was so much greater there would actually be a cooling effect.

There is another point in connection with radiation from superheated steam lines. Both of the authors* show the temperature inside the steam line, then a gradient through the covering and then another one from the surface of the covering into the air.

Is it not possible with superheated steam that a similar drop occurs between the steam and the inner wall of the pipe, so the actual temperature at the inner surface of the covering is much lower than the saturated steam? A practical illustration of that, some years ago, was seen in testing an engine. We ran a test with saturated steam, had a superheater on the boiler, and after running the test ran the superheat—and were surprised to find we did not get any superheat in the engine, with 125 deg. of superheat in the boiler.

We found that by blanking off a dead end of the pipe we got some superheat on the engine. We then put a nice covering of hair felt around that pipe, and found it did not last very long. The hair felt caught fire at a "T" near the engine and at no point else, which I always thought did indicate just such a phenomenon as suggested above—that the temperature of the wall was far below the steam temperature except at the "T" where the steam impinged violently on the wall.

L. B. McMILLAN: Referring to the question as to the drop in temperature from superheated steam to the inside surface of the pipe, this drop is usually quite small in proportion to the total temperature drop, particularly in the case of insulated pipes. The reason for this may be shown as follows:

Using a value of 32 B. T. U. per sq. ft. per degree temperature difference per hour as the rate of heat transfer between superheated steam and pipe wall[†] the resistance to heat flow at this point is 1/32=0.031. With an insulation having a resistance of 4.0, the total resistance would be 4.031. Since the temperature drops across resistances in series are proportional to the resistances, it is apparent that the temperature drop from superheated steam to pipe wall is of the order of 1% of the total drop from steam to air. In the case of bare pipes, however, the temperature drop from superheated steam to air would be much greater and may be of the order of 10%.

Referring to the question of losses from very small pipes, it is true that in the case of very small cylinders such as heated wires the rate of heat dissipation may be increased by covering the surface. The maximum heat loss will occur when r2=Rsxk in which r2 is the radius of the outer surface of the covering, Rs is the surface resistance and k is the conductivity of the covering. For example, if Rs=.5 and k=.5, r2 for maximum loss would be .25". If the radius of the pipe is less than .25" the addition of covering will cause an increase in heat loss until the thickness is such as to give an outside radius of .25". Application of still more insulation will cause a lowering of the rate of loss from this point on.

If the radius of the pipe is greater than .25" under the above conditions the application of covering will cause a reduction in the rate of loss from the outset and there is no point at which the rate of loss will increase again. It is apparent, therefore, that in connection with insulations of low conductivity the increase effect will occur only for pipes of very small size.

[†] B. N. Broido, Transactions ASME Vol. 44, page 1211.

The Flow of Water Through Culverts

Pamphlet of 128 pages with plates and diagrams. Price $1.00 net. This is a report of an investigation, and careful experiments, conducted by the Bureau of Public Roads, U. S. Department of Agriculture, and Professors Floyd A Nagler and Sherman M. Woodward, University of Iowa.

The investigations were undertaken primarily for the purpose of determining:

1. The quantity of water that will flow through culverts, or sluiceways of different materials, sizes, and shapes under conditions of actual use.
2. What conditions tend to increase or decrease such quantity.
3. What principles should be followed in design to secure the greatest discharging capacity for the least cost.

The report describes the methods of making the tests and presents the experimental results together with the discharge formulas developed for the various types. It contains much information of thoroughly practical value as to discharge capacity for concrete pipe, vitrified-clay pipe, corrugated-metal pipe, and concrete box culverts.

Copies can be obtained from ENGINEERS & ENGINEERING. U. S. 103, Bul. 1.

Diesel-Electric Tankers

The Atlantic Refining Company will recondition and place in operation early in 1927, three Diesel-electric tankers—among the largest of their kind in the world—for operation in trans-Atlantic service. These tankers were purchased from the Shipping Board and were formerly known as the "Sharon J," "M. Connally" and "Bessemer"—each 7,000 dead weight tons. They were formerly operated by steam.

Each tanker will be equipped with three 850-horsepower, 225 r. p. m., Diesel engines, each driving a 525-kilowatt, 250-volt generator for propulsion and a 50-kilowatt, 250-volt auxiliary generator for excitation and ship's auxiliary power. The propulsion generators will supply power to an 1800-horsepower, 90-r. p. m., 750-volt double motor to be direct connected to the propeller shaft. The control will be of the Ward-Leonard type arranged for operation either from the pilot house or the engine room, the panels being of the dead-front type throughout.

The tankers will be fitted with electric auxiliaries, including two 80-horsepower cargo pumps, one 45-horsepower windlass, one 30-horsepower mooring winch, one 30-horsepower fire and bilge pump, two 15-horsepower air compressors, a balancer set and numerous small pumps—as well as a 25-kilowatt auxiliary generator driven by a small oil engine which will be used for emergency and in port.

Human Engineering*

By ELISHA LEE,

Vice President in Charge of Operation, Pennsylvania Railroad System

I AM going to talk this noon more particularly to the younger members in the club and in the engineering profession. I am going to talk rather ramblingly, perhaps, although it is a subject in which we all should have very deep interest.

A short time ago I was asked, along with other railroad executives, by the editor of an engineering magazine, to state my views on what I considered the greatest problems of railroad management in the present day. I replied that they were without exception problems of human relationship; that in the early days of railroading technical questions predominated, but that the best brains among railroad managers at the present time are devoted to problems involved in handling and getting along with people in masses.

Industry today demands human understanding, if mankind is to keep pace with the gigantic strides made along mechanical lines. Inventive genius has created, and is still creating, so much machinery that is revolutionizing our methods of doing things, that executives have been forced to give a great deal of thought and time to the study of what is sometimes called "Human Engineering." The growth of business from small companies of a few hundred employes to large corporations employing thousands has been another factor in quickening the need for a more general understanding of what goes on in the worker's mind. Big business has obliterated the personal touch. There is no longer an opportunity for the executive to meet all the men individually under his supervision. Modern life also has a tendency to repress what is generally known as the creative impulse—the desire to create is as fundamental as life, for life is creation. That is why I believe that if you can paint the picture of the part each individual worker's job has in the whole manufacture of an article, you have changed him from a routine worker into a creator. Give the worker the proper viewpoint of his job, and you have done much to prevent discontent and labor turnover.

One of the best illustrations of this point that comes to my mind is that of a man who questioned three stonemasons as to what they were doing in working upon a large church edifice. It is an old story, but illustrates the point more clearly than anything else I can think of. One replied, "I am just laying stone;" the second answered, "I am working for $10.00 a day;" the third, throwing out his chest, said, "I am building a cathedral." It should be the duty of all men interested in human engineering to endeavor to inculcate in the minds of his co-workers that they are not merely toiling for bread and butter, but that they are building cathedrals. Then they advance from laborers into creators.

Desire to get ahead is another fundamental rule of mankind. Whenever you find a man entirely satisfied with his lot in life, there is very likely something wrong with him. It is the natural right of every individual that he should feel he is preparing himself for bigger and better duties, and this urge for promotion should not be overlooked. The desire to advance in his chosen work is at the bottom of the heart of every thinking individual. Snuff out that desire that is held dearest of all, and you have disgruntled workmen, for you have taken away the goal of all ambitious employes. Promotion is individual realization, and shows that effort merits reward.

It is my opinion that when an executive is confronted with the problem of placing a new regulation into effect that if he will place himself honestly in the position of those affected, he will find his reaction will very nearly approach those most deeply concerned. With this knowledge he will at least be better able to chart his course properly. This is a fundamental step in the study of human engineering, to know that under similar circumstances almost all mankind will react the same. It is of paramount importance in maintaining cordial relations with your workers. No matter what the difference in rank, in position, I have found that the right thinking workmen need the same fundamental things in life that I do. The laborer has the same love for his home and family that an executive of a corporation has. He has his prestige to maintain in his community, and strives to live accordingly. And he furthers wants to earn a litte more than his bare expenses, so that he can save and live in a sense of security in case the proverbial "rainy day" should arrive.

All this leads to another step in human relations, that of influencing mankind along the right lines. Much has been written on influencing human behavior, but no one has summed it up more briefly than the ancient philosopher when he declared, "Virtue can only be taught by practice." Time has not changed the wisdom of this declaration, because you can't say one thing and do another and get away with it—very long.

Honesty, truthfulness, loyalty, frankness and morality are the major virtues expected of an employe when being hired. Likewise, he admires these same traits in his employer. With the building up of this spirit of frankness, and the demolishing of the feeling of distrust, workmen now do not look askance at overtures of their employers.

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*Address before the Engineers' Club, April 13, 1926.

Of the many new thoughts that have entered business in late years, that stand out prominently, is this desire for frankness between employer and employe. I ran across, in one of the railroad magazines, the other day, a talk by a superintendent of the Erie Raliroad, who expressed certain thoughts in connection with this big matter better than I ever heard them expressed before. I am going to quote you some of them: "It is our duty to get results, to get our men to act safely and correctly, and we are morally responsible for their training and their actions. How do we measure up to this responsibility? Most of our working hours are spent in dealing with human nature, investigating, inspecting, influencing, correcting or disciplining men. It is our job not simply to punish, or to apply discipline so that we can say that some action has been taken, but to correct and reeducate the men who make errors and who are out of tune with the rest of the organization. It is not the amount of discipline, but the way it is handled by the local officers that determines the reaction of the man involved, and therefore it requires a large amount of tact.

"Yet, how much study is given this question? Man is the most marvelous machine that has ever been constructed. He works efficiently with a daily portion of fuel, he is maintained automatically, his combustion and lubrication are perfectly arranged—at least at the start. The extent of his capabilities has not yet been reached, but it must be admitted that very few of us have studied human beings as an engineer studies engineering, as a craftsman learns his trade, or a professional man his profession. Let us analyze the question. We are dealing with human beings, and we all have similar aims and desires. We are selling our services in return for a stipulated wage; we all have ideas concerning our jobs. If the job is to our liking and we become enthusiastic about our work, there is little question about our efficiency. As railroad men, we have the play instinct highly developed. We know instinctively that when we like our work we do not easily tire, and we know that when our hearts are not in it, our work becomes drudgery, and causes excessive fatigue. Therefore, let us analyze, briefly, the things that mean respect for a job. To do this, let us put ourselves in their places. We wish to overcome obstacles, accomplish difficult things. An experienced fisherman likes to catch game fish. They are difficult to catch. A golf expert likes to play difficult courses to bring out his skill. So, in our daily work, we take pride in accomplishing things that are more difficult than the average.

"Because we are creatures of habit, we like to have some regularity about our work and methods. Nevertheless, we like to have some new interest, some new problem to master, to keep life from becoming too monotonous. Therefore we like a mixture of variety and monotony.

"We want a chance to see results, to measure the fruits of work. In this we have the artist's instinct of creation, and take pride in a job well done. We want to work where we can have a feeling of loyalty to our company. We want that company favorably known, an institution that is worthy of our loyalty and cooperation. And along with this is the feeling that we want to work for a company that is loyal toward us as well. We all want to be treated like human beings, not as mere cogs in a machine, nor as a commodity. Each man likes to feel that he is an individual performer and that the character of his work is known to his superior.

"If a job does not meet these qualifications, a man will be discontented, and his work be indifferent. In fact, an analysis of most man-failures will show the cause to be a violation of some of these principles as far as he is concerned."

Now some of you might think from some of the things that I have said that an executive must be soft, perhaps what has been termed a "mush pot." Not true. There are, to my mind, three fundamental things. You older men know it; you younger men also probably know it. I call them the three F's. I used to consider two F's, but I think there are three. —Frankness, Fairness and Firmness.

Frankness melts into fairness, and it is hard to tell where the two separate. Getting down to Firmness and Fairness, frankly, I never have been able to fully convince myself which was the more important. Fairness, of course, is necessary in dealing not only with your subordinates but with your associates, and with the outside people, but firmness is also very necessary. If a man is in trouble, he wants to know what is going to happen to him. He doesn't want to be shilly-shallying back and forth for two or three days, told one thing today and another thing tomorrow. He wants to know when his boss tells him "yes" or "no" that unless there are some very serious things arise that that "yes" or "no" will stand. He doesn't want a "yes" as I said once before, at three o'clock and a "no" at four o'clock, and another "yes" at five o'clock. He wants to feel that when he gets his "yes" or "no" at three o'clock that there won't be any necessity for coming back at four or five o'clock for if he does he won't get any different answer.

Firmness and decision after thorough consideration, to my mind, are fully as necessary as fairness. I don't believe the successful executive can get along without either of them.

I have rambled on here for a while, but there are just two other things that I want to say to my younger friends. There are two virtues, and I call them virtues advisedly. One is common sense, and the other is a sense of humor. They will help you over many a hard road. You can often josh a man out of a thing when you can't reason him out of it, or you might be able to ridicule him out of it if you do it in a proper way when you can't talk logic to him. Common sense and a sense of humor will take you through many a battle and often bring you out ahead.

Experiences with the Combustion of Fuel Oil in Power Plant Boilers

By **J. F. BARKLEY**

Fuel Engineer, Bureau of Mines, Department of Commerce

IN the course of the Government's Fuel Economy Survey of its own power plants, studies and tests have been made of various oil-burning equipments under power-plant boilers. There are now many types of burners being offered in the relatively limited field of power-plant use, but the majority of the types used may be grouped into two general classes, those using steam to effect the atomizing of the oil, and those using mechanical means.

Burners using steam have had the most prominence in this field for a long period. The mechanical atomizing type of burner successfully applied on shipboard, however, pointed to a possible betterment in land work. The vision presented itself of a burner that would need no steam for atomizing, that would permit of air inlets or registers compactly arranged as a part of the entire burner, and that would require only the natural stack draft usually available in land boiler furnaces. Hense, rather recently there has been much development along this line, resulting in various types of burners.

In Table 1 are grouped test items chosen from many tests showing representative analyses of the products of combustion obtained with various burners installed in various types of furnaces. In all these tests the burners were handled by experts and represent practically the best attainable for that particular arrangement. The boiler efficiencies ranged from 70% to 80%. It will be noted that the burners using steam for atomizing were able to secure slightly better CO_2 and less O_2 without the presence of CO.

It is hardly proper to name such equipment on "oil burner." The mixing and burning is done in the furnace. It is quite important for it to have the proper shape and size to suit the particular burner used. The differences shown between the various mechanical burners would largely disappear if the correct furnace for each could be arranged. In the development of the mechanical burner much attention has been given to the devices for twisting the air and spraying the oil, but the important point is what happens after they get into the furnace. A cubic foot of oil at 60° F. requires about 11,000 cu. ft. of air at 60° F for correct combustion. For combustian to progress, it is necessary for a continuous stream of air to pass each small oil volume as it is sprayed into the furnace. The products of combustion must move away from the surface of this oil volume. This means that the air must have a different velocity or direction from the oil. Since twisting movements of air and oil imparted at the burner entrance are soon lost, the importance of furnace shape and size is apparent.

Table No. 1—Representative Analyses of Products of Combustion of Fuel Oil Obtained With Various Burners in Various Types of Furnaces

Type of Burner	Temperature of Oil, °F.	Pressure of Oil lbs. per sq. in.	Dry products of combustion		
			CO_2 percent	O_2 percent	CO percent
Mechanical natural draft					
Make "A".......	230	121	11.6	5.4	0.1
"A".......	185	152	10.2	7.4	0.0
"A".......	242	101	10.1	7.4	0.0
"B".......	285	195	10.3	6.4	0.0
"B".......	252	150	10.6	6.6	0.2
"C".......	66	87	12.7	2.9	0.0
"C".......	326	248	12.2	4.2	0.1
"C".......	254	183	10.4	6.8	0.0
"D".......	264	182	11.4	5.3	0.1
"E".......	324	205	12.2	4.0	0.2
"F".......	286	202	11.9	4.0	0.3
"G".......	261	221	11.1	5.7	0.0
"H".......	260	139	12.9	3.6	0.1
"I".......	204	247	12.4	4.3	0.0
Steam Atomizing					
Make "M".......	142	46	13.3	2.8	0.0
"N".......	194	43	14.1	2.2	Trace
"O".......	193	42	13.7	2.5	0.0

In the combustion of an oil particle it is the carbon that is the more difficult to burn. It separates out as soot at the slightest provocation, and causes much heat loss. This may happen from a chill at meeting

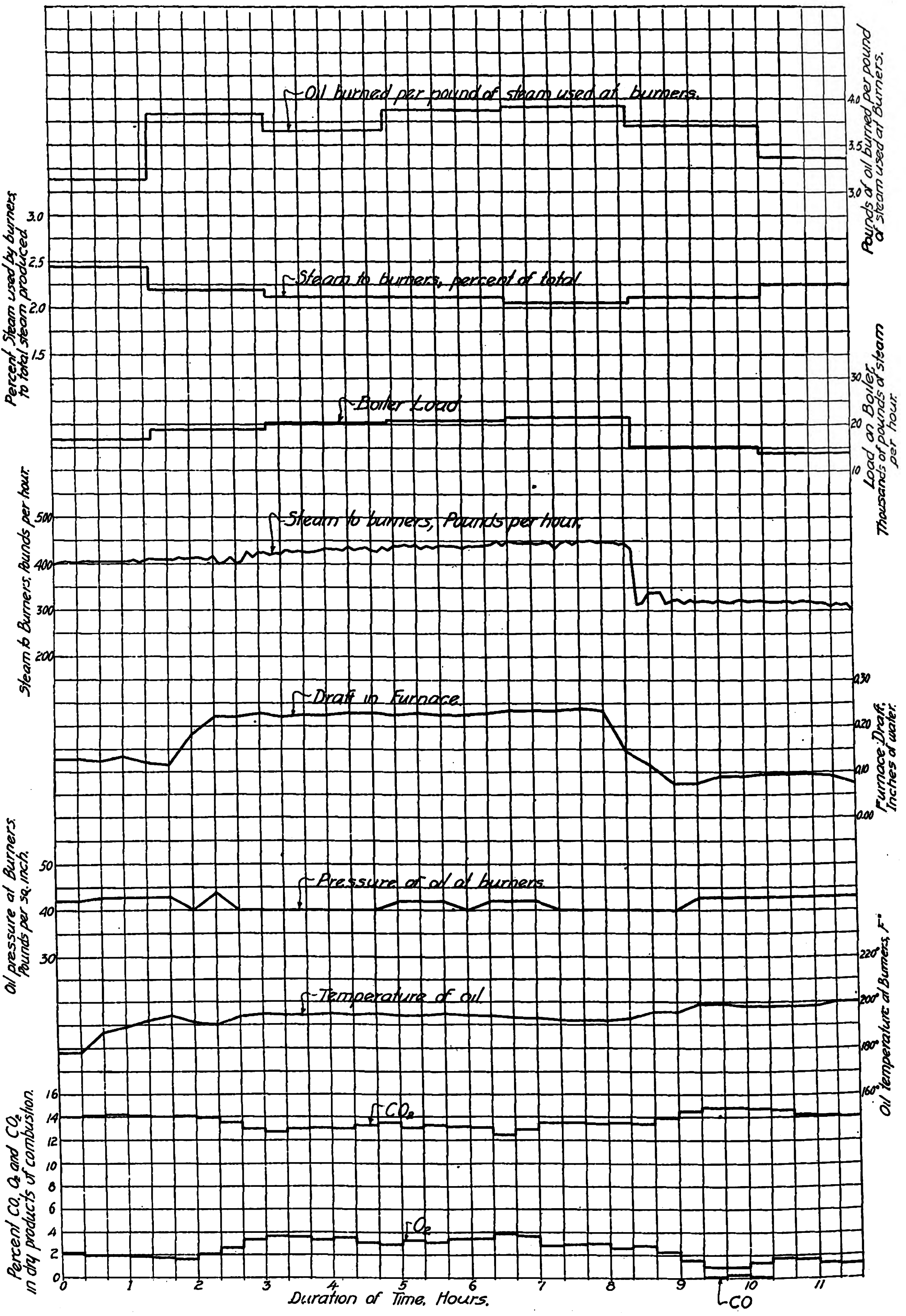

FIGURE 1. CURVES SHOWING VARIATIONS IN ITEMS OF TEST OF OIL BURNER USING STEAM FOR ATOMIZATION

the boiler tubes, or a lack of air at the right moment. This may occur without the slightest indication in the usual flue gas analysis. To illustrate, the following data are take from Bureau of Mines Bulletin 214, by H. Kreisinger and others. These samples were taken at a spot in a furnace just before the gases entered the tubes. They are quite representative, however, of completed combustion in some furnaces:

% CO_2	% O_2	% CO	Soot (Grams per cu. ft.)	Soot (Per cent carbon in oil)	Heat in Soot (Per cent heat in oil)
11.6	5.0	0.0	0.174	9.5	6.3
11.2	5.6	0.0	0.123	7.1	4.8
12.4	3.9	0.0	0.123	6.5	4.4
12.3	4.5	0.0	0.237	11.9	8.0
14.2	2.0	0.1	0.076	3.6	2.4
14.5	1.2	0.2	0.172	7.5	5.0

It will be noted that there is a great heat loss even when there is plenty of O_2 and no CO. In the next to the last sample CO had appeared, but there was less loss due to soot. In general, however, along with CO and O_2, loss due to soot may be anticipated as shown by the last sample. In ordinary testing practice, the special equipment necessary to determine the soot loss is not always available. The soot loss appears in the heat balance as a high "unaccounted for" loss. The analysis of the products of combustion without the soot factor being taken into consideration, may lead to false conceptions, particularly in the correct design of furnaces.

It might be expected that the mechanical type would require more steam for pumping and heating the oil, but in actual practice the amount of steam used is affected by so many factors, such as efficiencies of relatively small pumps and heaters, amount of oil circulated, etc., that this consistency seldom appears, as is borne out by the table. The steam used for atomizing shown in the table is an example of excellent practice, with expert firemen under test conditions. In Figure 1 is given a set of curves showing how this steam and other related factors vary over a period of time and at different boiler loads.

When these various burners are placed in the hands of the ordinary fireman for general operating purposes, the following has been observed: He finds that the mechanical natural draft burner is very sensitive, and requires delicate adjustments to get the best results. Where several burners serve one furnace, each burner has its own peculiarities. Frequently the fireman will get a deposit of carbon in the furnace in the form of a mound two feet high. Later he may burn it up and not just understand how it all happened. The burner is affected appreciably by small changes in the draft, such as are caused by various wind velocities across the top of the stack. It requires constant attention to maintain any close setting. A damper on the boiler that can be moved extremely small amounts with accuracy, is needed. Careful damper adjustment gives better results than continued adjustment of the secondary air registers. In general, the fireman is told that he has the best results when he is just getting a light smoke. He is probably warned not to make too much smoke, so he uses plenty of air and does not try to get too near the limit. A test condition of 11.6% CO_2 and 5.4% O_2 drops to 9.6% CO_2 and 7.4% O_2. Under these conditions he usually has a nice looking flame, can carry his load, and he ceases to bother a great deal about refined adjustments for efficiency.

When the steam atomizing burner is placed in the hands of the regular operating fireman, he seems to be able to operate it more closely to test conditions than he can the mechanical natural draft type. He

Table No. 2

Type of Burner	Pounds of steam used for oil pump and heater per pound oil as fired	Pounds of steam used for burner per pound oil as fired	Total pounds of steam used per pound of oil	Per cent of B. Hp. (total steam developed) used for oil pump and heater	Per cent of B. Hp. (total steam developed) used for burner	Total per cent of B. Hp. (total steam developed) used	Per cent of total heat of fuel to heat in steam used for oil pump and heater	Per cent of total heat of fuel to heat in steam used for burner	Per cent of total heat of fuel to heat in total steam used
Mechanical, natural draft	0.093	....	0.093	0.82	....	0.82	0.61	....	0.61
"	0.154	....	0.154	1.30	....	1.30	1.00	....	1.00
"	0.103	....	0.103	0.85	....	0.85	0.66	....	0.65
Steam atomizing	0.140	0.295	0.435	1.16	2.45	3.61	0.86	1.83	2.69
"	0.184	0.272	0.456	1.46	2.17	3.63	1.14	1.69	2.83

For each furnace arrangement there is a certain percentage of CO_2 that gives the best results. The rule of adjusting burners to secure a slight haze of smoke may at times be quite wrong, as this smoke haze can frequently be secured with various percentages of CO_2 for the same furnace. Furnaces in which the carbon of the oil constantly tends to "drop out" as soot often give greater overall efficiencies with considerable excess air. The exact way of establishing the correct CO_2 for a furnace is by a test where the water and oil is weighed.

In Table 2 are given some typical examples of the amount of steam required by the two different classes of burners for atomizing and for oil pump and heater.

uses very little more steam. In one instance, a plant engineer declared his steam burners must be using at least 10% of all the steam he made. Whenever there were periods in which he had difficulty in carrying the load, he quickly arrived at the conclusion that the trouble was due to the amount of steam used by the burners. When the steam was measured it was found he was using about 3%. With some types of burners this will rise to as high as 5%. Regular operating conditions of 13% CO_2 are not unusual, for the better class of burner and furnace arrangements.

In making a comparison of the two types discussed, as far as efficiency only is concerned, the following might be considered. The mechanical natural draft type has the advantage of the steam type by, say 2% to 3% of the total heat in the fuel chargeable to the latter's use of steam for atomizing. In order to compensate for his handicap, the steam type must be able to obtain better combustion, so that the loss in the dry flue gases is less than that obtained with the mechanical type. For example, a CO_2 content of 9.6% gives about 3% more loss in the dry flue gases than 13.0% CO_2. Much effort and study have been put upon the furnace in the use and development of the steam type. The solution of the problem in the development of the mechanical natural draft type, which is at a disadvantage when compared to the forced draft type, is in furnace study rather than concentration on burner arrangements.

Electrolytic Iron[*]

A Metal of Great Purity, Ductibility and Malleability

FOR millenniums, man has used fire for extracting iron from ore. To bring together ores, fluxes, fuels and other supplies at suitable places in quantities to satisfy modern needs necessitates transportation on a prodigious scale. But there are huge deposits of iron ores remote from fuels, yet relatively near regions of large potential demand for iron and steel and not far from waterfalls by which electricity could be generated cheaply. For years scientific men have been trying to produce iron directly from its ores by means of electricity.

There is another problem which concerns us all. Of the iron and steel produced by so great expenditure of energy, 20,000,000 tons are estimated to slip away each year by corrosion. Not only are expensive finished products lost, but the indirect costs are very great for temporary prevention, repairs and replacements. Cannot electricity help in producing, at reasonable cost, iron which will rust less rapidly or not at all?

Furthermore, discarded iron objects, from cans to automobile bodies, are increasingly disfiguring the countryside, especially in proximity to communities. Could not large tanks of iron solvent, ferrous chloride, for example, be maintained in convenient places, into which these wastes could be dumped? Then the iron could be recovered by electrolysis. Other aspirations also are entertained by forward-looking metallurgists.

Visionary? Generations away? May be not! And "Where there is no vision, the people" are perishing. They may not suspect danger, for the early steps of decadence are easy and pleasant.

But how far have the electrolytic iron men progressed? About fifty years ago, iron was produced electrolytically by Elihu Thompson and Edwin Rice but found so hard, rough and brittle that nothing was done with it. Since then many patents have been issued in France, the United States and other countries. A few years ago, the most successful concerns in France and the United States found that each had knowledge and patents that would be valuable to the other. They combined forces. In America the Niagara Electrolytic Iron Company has rehabilitated a chemical plant, recently purchased at Niagara Falls, and is commercially producing iron of a purity of 99.96 per cent, while continuing research and development. This iron is resistant to corrosion and has advantageous physical qualities.

The process begins with large bars of cast-iron, which, as anodes of huge batteries, are dissolved in the electrolyte of ferrous chloride. From this solution the current deposits the practically pure iron on the cathodes, which are long, thick, hollow steel cylinders with smooth surfaces. The cathodes are revolved slowly and the electrolyte is kept in constant circulation through the battery cells, or tanks. These cells are of reinforced concrete impregnated with 5 per cent, by weight, of sulphur.

On each cathode the electric current builds a seamless tube of iron ordinarily 9½ inches internal diameter and 13 feet long, of any thickness desired, up to ¼ of an inch. Diameter and length of tubes can be varied using cathodes of different sizes. Thickness depends upon time and current. The initial deposit is full of hydrogen, which embrittles the iron.

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[*] Engineering Foundation, Research Narrative, No. 116. Based on information supplied on request by Charles P. Ferin.

Therefore, the cathode and the adhering tube, upon removal from the battery, are passed through an oil-fired annealing furnace, which removes most of the hydrogen.

For removal from the cathode a special stripping machine is used which enlarges slightly the diameter of the tube by kneading the iron between the cathode and three rolls which are forced against it by hydraulic pressure. Then the tube is further annealed in an electric furnace. The cathode is returned to the battery. The electrolyte is regenerated in special tanks by aid of steel scrap and is used continuously.

By slitting, flattening and rolling, the tubes may be converted into plates of any desired thinness. Or the tubes may be slit into narrow strips or into coils for drawing into rods and wire.

Seamless tubes for steam boilers, condensers, evaporators and oil-racking stills, may be made to advantage from this iron; also containers for compressed gases, automobile mufflers, paper mill rolls, deep stampings and many other articles for which great purity, malleability, ductility, or resistance to corrosion are desired. And so by patient research, courageously supported by men of faith, the world is being enriched by a new group of industries with great possibilities.

NEW BOOKS

BOOK REVIEWS

Geology Applied to Mining—New Second Edition—A first book of General Geology and Metallology. By Josiah Edward Spurr, Editor-in-Chief, Engineering & Mining Journal-Press. 361 pages, pocket size, flexible, 124 illustrations. $3.00.

Contents—I—Sediment and Sedimentary Rocks. II—Igneons Rocks and Magmas. III—Bending and Breaking of Rocks. IV—Deep-Seated Concentration of Metals. V—Concentration of Metals at and near the Surface. VI—Ore Deposits and Geologic Periods. VII—Ore Deposition as Controlled by Faults, Fissures and Folds.

Corrosion: Causes and Prevention—An Engineering Problem. By Frank N. Speller, Director of Metallurgical Department, National Tube Company, 621 pages, 6x9, 125 illustrations. $6.00.

A systematic presentation of the available information on the corrosion problem. The book combines in one volume a thorough treatment of the theory of corrosion and a detailed description of the developments in the prevention of corrosion. It deals particularly with the ferrous metals.

Practical Coal Production—Getting Out the Coal. By Frank H. Kneeland, Associate Editor, Coal Age. 403 pages, 5⅛x8, 302 illustrations. $3.00.

In this volume a detailed treatment is given to methods of getting coal out of the mine—from surface mining to loading and conveying coal, from underground methods to the best practice in timbering and roof support. Only methods which have been put to practical and successful use are included.

Public Utility Regulation—A thorough survey and discussion. Edited by Morris Llewellyn Cooke, M. E., Sc. D. 310 pages, cloth. $3.25.

Presents in serviceable form material which will be helpful to all those directly or indirectly interested in this subject. It deals not only with valuation but also with such equally important subjects as apportionment of control, service standards, cooperation between state and local authorities, and labor policies.

This new survey covers the whole field of regulation of public utilities by the states and to some extent by local and federal authorities. It has been prepared by a group of leading engineers and administrators, from thorough investigations recently made by them.

The Fundamental Concepts of Physics in the light of Modern Discovery, Three Lectures at the Carnegie Institute of Technology, Pittsburgh, January, 1925, by Paul R. Heyl, PhD., Physicist, Bureau of Standards. xii+112 pp. 4¾x7¼. $2.00.

"Materialism," "correlation," "hope;" these subtitles of the three chapters strike the keynotes for the three centuries, each contributing its part in the grand march of science. The book, as a whole, is a clean cut compendium of the growth of science since it really began to grow. There are few who will not find it a help in pigeonholing what they know and what they do not know and why.

Practical Accounting for General Contractors—By H. D. Grant, Staff of W. B. Richards & Co., Accountants and Engineers; formerly with the American Woolen Company; Field Auditor for the U. S. Government. xii, 329 pp., 5½x9. Second Edition. 1925. Cloth, $3.00.

"The need for a comprehensive work on accounting for contractors was brought home to the author some years ago when engaged to take charge of the accounting department of a large contracting concern . . . After a period of close observation and experiment, a system of accounts and accounting control was evolved which fulfilled the essential requirements . . . This book in part contains a description of the system to which is added a discussion of the methods and accounting practice that have become the standard practice in these contracting businesses where adequate records are kept." From Preface to First Edition.

The system of accounting described in the first edition was devised to meet the requirements of contractors engaged on large operations. . . . A contractor who operates in a small way . . . would not need such an elaborate system of accounts. To provide for both. . . . the author has, in this second edition, outlined an accounting system which . . . would be adequate . . . for a contracting business of ordinary size. From Preface to Second Edition.

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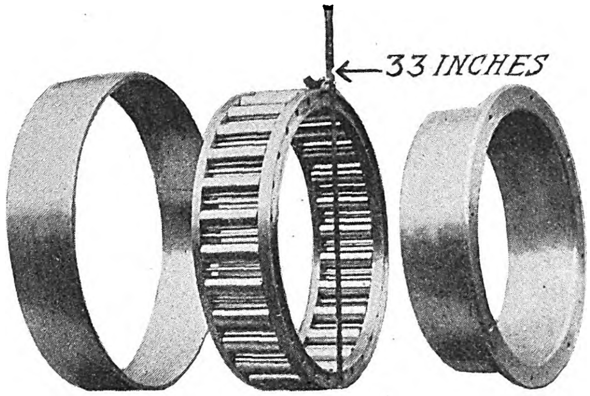

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UNITED STATES CIVIL SERVICE COMMISSION, WASHINGTON, D. C.—John T. Doyle, Secretary, is experiencing difficulty in finding sufficient number of assistant architects for employment in connection with the huge building program, to be carried on by Office of Supervising Architect, Treasury Department. Asst. Architect's salaries, $2,400 to $3,000; Architectural Draftsman's salaries, $1,680 to $2,400.

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ENGINEERS & ENGINEERING

SEPTEMBER 15, 1926

Vol. XLIII FOUNDED 1879 No. 9

Business and Banking

OPTIMISM continues to influence nearly all studies of the outlook for business. None of the fundamental industries have shown either recession or slowing down that might not have been anticipated as one of the conditions of the summer season. It has been both mid-year inventory and holiday period and, logically, the business momentum of a couple of months ago lessened. From preliminary figures it seems certain that the net operating revenues of steam railroads will top the record for the month of August and for eight months of operation. This is a dominating reflection of the prosperity of the year and there is nothing now in sight to indicate that good business, on the average, may not continue.

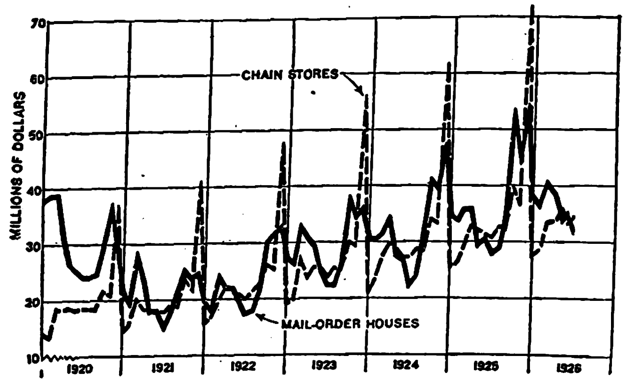
A striking illustration of the business condition is seen in the sales by mail-order houses and five-and-ten-cent chain stores. During the year 1924 Sears, Roebuck and Company and Montgomery Ward and Company, the two largest factors in mail-order merchandising, sold goods to a total value of $356,475,592. During 1925 their business aggregated $414,390,993, an increase of just under 16.25 per cent, or an increase in dollar sales of $57,915,401. Using actual figures for the first six months of this year, then it appears that the 1926 increase over the total sales of 1925 will be at least at the percentage of the last year, as shown above. And since a very considerable portion of these sales are made to the people of the rural districts, it seems fair to believe that the farmers and their families not only are able to buy the things they may want, but that they are able to buy in increasing quantities.

Commenting on the unusual increase in sales by Sears, Roebuck and Company, Mr. Julius Rosenwald, Chairman of the Board of that company, recently said:

> "Our biggest increase in volume of mail order business has been in strictly agricultural territory. This is convincing evidence of economic recovery on the farms. Kansas is probably the outstanding example of this improvement in the agricultural situation. Iowa is about holding her own. The only states in which a satisfactory improvement is not reflected are the Dakotas and Minnesota."

Since then, according to the Map of the Nation's Business, improvement has spread across Minnesota and North Dakota so that, in the north-central section of the country, only South Dakota and the western boundary of North Dakota now remain below the general average of the states as a whole.

The business of the chain stores does not appear to the writer to carry the same important significance. The companies add to or take from the number of stores distributing goods and from time to time change the amount of capital employed in the production of sales. However, F. W. Woolworth and Company and S. S. Kresge Company, the two largest organizations of "Five-and-Tens" reported gross sales aggregating $305,710,856 during 1924 and $349,258,871 during 1925. The Department of Commerce in its Survey of Current Business emphasizes these increasing sales as one of the basic industrial and commercial movements and illustrates the trend in the chart here shown.

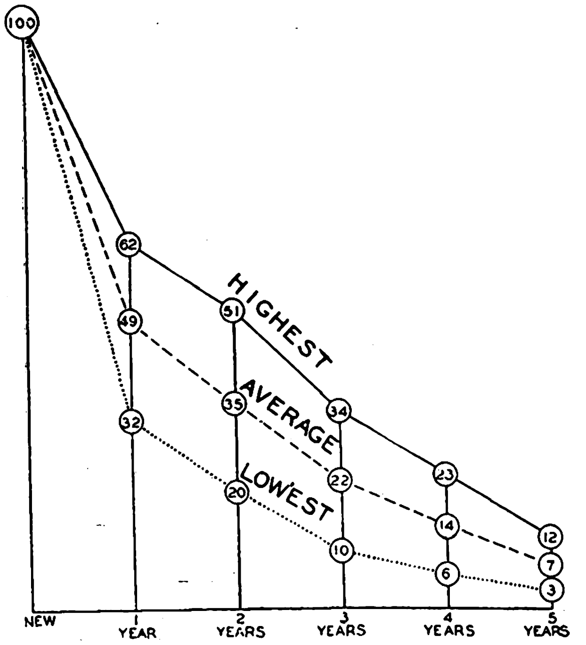


Courtesy of the Department of Commerce, Washington.

SALES BY MAIL-ORDER HOUSES AND TEN CENT CHAIN STORES

July sales of automobiles, reported by fifteen distributors to the Philadelphia Reserve Bank, were smaller both in the number and value of cars sold than in the previous month. Wholesale transactions were less for all classes of cars, but the largest declines were in the low-priced and high-priced groups. And even though manufacturers announce plans for speedier production and larger sales, it is no more than right that in this industry the bulk of the year's business should be done during the first six months. Commenting on the prices of used cars as one of the factors in automobile merchandising, Col. Leonard P. Ayres, vice-president of the Cleveland Trust Company presents a curve that will be interesting to users of cars and says:

> "The diagram is based on data from one of the recent trade reports on prices of used cars. The quoted prices of thirteen makes were used. The figures show that if the price of each car when new is taken as 100 per cent the one showing the least depreciation after one year of use had then a market value of 62 per cent of its original price. The average car has a value at the end of the first year of only 49 per cent of first cost, and the car showing the greatest depreciation among these thirteen makes is worth, after one year's use, only 32 per cent of its cost when new.



Courtesy of Cleveland Trust Co.

USED CAR PRICES (13 MAKES)

The corresponding figures for the second, third, fourth and fifth years are shown in the small circles of the diagram. They show that the typical passenger automobile loses about one-half its selling value in its first year of use, about two-thirds in the first two years and over three-fourths in the first three years. The depreciation of the most durable cars is so much slower than that of the least durable, that after several years of use they are worth from two to four times as much as their more fragile competitors.

> The market value of a car that is five years old is discouragingly small. The best record among these thirteen makes is 12 per cent and the poorest one only 3 per cent of the first cost."

* * *

Textile industries, which have been lagging for some months, report improvement, with the markets slowly broadening. The month of August developed better buying of print cloths at rising prices, and this, with cotton crop estimates smaller than has been heretofore antcipated, undoubtedly brought about the improvement in merchandising.

Steel production continues at a fair level, mills operating at about 80 per cent of capacity. Early estimates are that the United States Steel Corporation's unfilled orders for August will run about the same in tonnage as July. There was slight recession in buying during the early weeks of August, but in the last week considerable business developed and lifted the average for the month. Shipments during August were about 50,000 tons more than during July. And since conditions in the steel industry in the various sections of the country have averaged much the same up to August, it is assumed that the conditions of the United States Steel Corporation are reflective of the conditions of the industry in general.

* * *

An important development in the money market during August was the advance of the discount rate in New York from 3½ to 4 per cent. This was brought about by the transfer of funds for crop moving and by larger commercial requirements such as stocking up for fall trade and perhaps the anticipation of a very large business toward the close of the year. The National City Bank expresses borrowing as on the up-grade, and if it follows the normal seasonal course, borrowing will continue to increase until around the middle of October. The money rate has been influenced also by a revival of speculation in the stock market with an increase of over $300,000,000 in brokers' loans from the low point in May.

Prices of stocks averaged higher at the close of August than at the beginning, even though quotations were erratic during the entire month. There were numerous declines and the average quotation was supported by activities in specialties and particularly various of the steam railroad issues.

At the beginning of September the average quotation of twenty industrial stocks was practically at the same point as at the opening of the year, when quotations continued sharply upward only to fall at the end of January and to break again in February and in March. At the close of the month, the average price of twenty active railroad stocks, which had been given preference in the trading, was near the highest —this indicating that further price advances are to be expected. In fact it was the opinion of some, who study stock quotations, that prices would work further upward, railroad issues to show more appreciation, on the average, than either the stocks of industrial or public utility companies.

An article in the Atlantic Monthly by Prof. W. Z. Ripley affected stock prices somewhat toward the close of the month, the article being on the subject of meagre reports made by some of the corporations to their stockholders. It seemed not to be of itself important, since it told little that is new. But it showed most clearly the delicate stage that the stock market, as a whole, is in, and illustrated how little it needs to cause a sharp downward turn in the quotations of speculative securities. It is understood that Professor Ripley's next writing will have to do with the stocks of public utility corporations, and especially holding companies.

But while the speculative market was active during August, investments were slow. Prices held firm, but new security underwritings were few and, with the exception of $30,000,000 of bonds sold by the Westinghouse Electric and Manufacturing Company for refinancing, of small volume. In fact, the chief issues of the month were bonds sold for the purpose of paying off earlier issues carrying higher interest rates.

The intimations at this writing are that financing through bond issues during the early Fall will be for foreign account and for the railroads. There will be good demand for sound issues from individuals, and, later in the season, a large volume of investment by banks and other financial institutions.

FREDERICK CARLES

Items of Interest

Conviction Under Registration Act

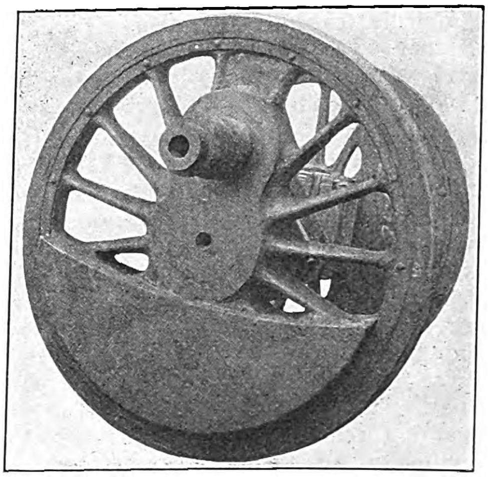
Recently Judge VanZile of Michigan rendered a decision upholding the state law requiring all Architects, Engineers and Surveyors to be registered. The case, against a well known Detroit man who for some years had been practicing under the title of Architect, was started through the Prosecuting Attorney's Office by the Michigan Society of Architects. The defendant pleaded that he had made application to take the State examination, but had not received notification of the time it was to be held. The judge withheld his decision pending the defendant's taking the next examination. After the examination was held the defendant failed to pass. Judge VanZile found him guilty of violating the State law. The penalty, according to law, is a fine not to exceed $100, as well as a jail sentence. In this case sentence was suspended since it was the first tried under the act and had for its purpose the establishment of a precedent for future cases. The significant part of the decision was that any person practicing or representing himself to be an Architect, Engineer or Surveyor without being duly registered, according to the laws of this State, would be held in violation of such laws and subject to a penalty at the discretion of the court.

The Michigan Society of Architects has for some time been collecting photographic and documentary evidence covering practically every violation in this city and state. A fund has been set aside and attorneys have been employed to take up the cases one by one until the situation has been remedied. The purpose of this law should be plain to every one, in that it protects the interests of the public against the unscrupulous and incompetent persons purporting to be Architects, Engineers and Surveyors. Everyone recognizes the importance of such a registration law regulating the practice of medicine, law and various other professions.

Practically every state in the Union now has a registration act similar to our own, which have been upheld in various courts. A more recent decision in the State of Washington was very broad in its interpretation, holding that the intent of the Legislature in passing the act would govern and that all of the technicalities under which some violators attempted to practice were only subterfuges and that any person so violating had no standing in court and could not recover for his services.

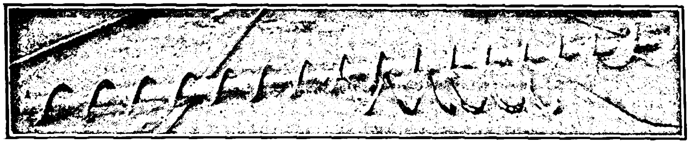
Repairs by Welding

Two interesting examples of repairs by welding are shown in the accompanying cuts. In one instance a repaired locomotive driving wheel is shown and, in the other, a worn stoker conveyor screw which is to be reinforced.



The driving wheel shown is six feet in diameter. Breaks often occur in the spokes where the wrist pin takes the driving thrust. The cracked spokes are cut through and beveled with the cutting torch and ground off to remove all scale. The spokes are welded using a 3/16-inch electrode and 160 to 170 amperes.

No preheating nor any special precautions are necessary to take care of expansion or contraction. In the space between the spokes is placed a steel reinforcing plate, 1½ inches thick and beveled at the edges to make easy welding. The plate distributes the strain over a larger area and no driving wheel repaired by this method has ever broken in service. To repair two spokes and weld in the plate is a four-hour job for two men.



Conveyor screws used in automatic stokers are made of cast steel. In this work there is a natural grinding and abrasive action which wears the blades or flights of the screws. A screw often wears down in six months. Usually the full length of the screw is not worn, but one end being affected, and about $12 spent for welding will reclaim it.

The World's Greatest Suspension Bridge

The story of the cables of the Delaware River Bridge between Philadelphia and Camden is told in a remarkable collection of photographs which give the best possible impression of the methods used in forming and putting in place the 30-inch diameter cables, each 3,540 feet long, with a total weight for the two cables of 6,750,000 pounds. A limited number of copies is available for distribution.

LARGE ELECTRIC GENERATORS FOR SOUTHERN CALIFORNIA

The Southern California Edison Company have ordered two electric generators, each nominally rated at 90,000 kilowatts at 90 per cent power factor or 100,000 kilowatts at unity power factor, to be driven by the two largest single turbines ever made.

Two unusual features have been incorporated in these machines. The armatures are being built with special heavy construction so as to be gas-tight, for the possible future adoption of the new system of hydrogen cooling. The machines are also the first to have a double-flow low-pressure end and four vertical condensers; with advantages of a simplified foundation and increased space for removal of condenser tubes. The total length of each turbine-generator will be 103 feet and the weight 1,650,000 pounds.

These machines will produce current at 16,500 volts; the highest with turbine-generators at the present time is 14,000 volts. Going above this figure to 16,500 volts means simplification of the switching problem and a reduction in the cost of the transformers which will be used in stepping up the voltage to still higher figures before the current is fed into the transmission system.

The turbines are of the tandem-compound type, with a rating of 94,000 kilowatts at 90 per cent power factor, or 105,000 kilowatts at unity power factor. A tandem-compound steam turbine is in reality a single machine, in that all of the equipment is mounted on the same shaft, that only one generator is used, and that the flow of steam is continuous.

Each of the main generators will operate at 1500 r.p.m.; they will produce current at 16,500 volts and 50 cycles. In addition to the main generators, each unit is equipped with a house service generator on the same shaft, rated at 4,000 Kw. at 80 per cent power factor of 5,000 Kw. at unity power factor.

The steam turbines driving the generators will receive steam at a pressure of 400 pounds gauge and a temperature of 725° F. The exhaust steam is at a pressure of one inch absolute, so that practically all of the energy of the steam is extracted by the turbines.

Reductions in Freight Rates Analyzed

Savings for Last Four Years Total $2,339,344,000

The commerce of the country is being moved during the current year at reduced freight rates, as compared with those in force in 1921, which will probably effect a saving of more than $733,000,000. In the year 1925, the exact reduction in freight rates, as compared with the rates in force in 1921, totaled $733,028,000.

Reductions have been made in the general levy of railway freight rates which have amounted in the four years 1922-1925, inclusive, to $2,339,344,000. These figures cover Class I railroads.

Actual tonnage and savings have been as follows:

Year	Tons of Revenue Freight Carried One Mile	Decrease in Receipts Per Ton-Mile Compared with 1921 (cents)	Reduction
1922	339,285,347,571	0.098	$332,500,000
1923	412,727,228,422	0.159	656,236,000
1924	388,415,312,335	0.159	617,580,000
1925	414,139,835,000	0.177	733,028,000
Total			$2,339,344,000

Upkeep Per Freight Car in 1925 Was Only $155

Analysis Shows It to Be the Most Economical Unit for the Transportation of Goods in the United States

The most economical unit for the transportation of goods in the United States is the freight car. An analysis of expenditures on the Class I railroads of the country shows that for the year 1925 they spent $155 per freight car to keep it in running order; $1,552 per passenger car; and $7,023 per locomotive. These expenditures seem small enough in themselves; the maintenance of a freight car, for instance, costing hardly more than a set of tires for a good automobile. Yet, multiplied by the amount of equipment on these railroads we get a grand total of $946,245,179.

This total is exclusive of depreciation and retirement allowances on equipment and does not include any of the overhead cost of management and supervision.

Maintenance of equipment expenditures are approximately 20 per cent of the total annual expenses of operating the railroads and constitute one of the unseen elements of cost required to provide the country with adequate, efficient and safe transportation.

Railroads Lead in Reduction of Waste

Declaring that the policy of "weeding out the waste" constitutes the new watchword for both business and government, James Francis Burke, General Counsel of the Bolt, Nut and Rivet Manufacturers Association, cites the railroads as the outstanding exponents of this movement. In a recent address he said in part:

"The railroad men of this country, shortly after their systems were returned to them by the government, faced a deplorable condition of demoralization. But they took a coldblooded, philosophical view of what they must do to save the greatest railroad systems in the world. By cutting out industrial absurdities and reducing the number of units that were causing untold waste, they have put the railroads of America on a higher plane of efficiency than ever before marked their history.

"Here is an illustration of standardization and economy in railroad management:

"In the nineties, the railroads were using fifty-six different types of axles which, by 1921, they had reduced to six; fifty-eight journal boxes were reduced to six; twenty-six couplers were reduced to one; twenty brake shoes were reduced to one, and twenty-seven brake heads were reduced to one.

"Who is reaping the benefits? The entire American people."

NATIONAL INDUSTRIAL CONFERENCE BOARD, INC.

Increased Industrial Efficiency Benefits Labor

The great saving in the amount of human energy necessary to turn out a given quantity of manufacturing production, which has made itself felt particularly during the last few years, bids fair to be the most significant industrial-economic development of the twentieth century.

It has been generally accepted that employment fluctuates with production, on the assumption that, barring revolutionary changes in methods, a given labor force is necessary to produce a certain output. This was substantially true, from 1900 to 1914, but during the past decade employment in manufacturing has to an increasing degree failed to keep pace with the increase in output, and this tendency has become particularly noticeable since the year 1921. Although the volume of manufacturing output from 1921 to 1925 increased about 62 per cent, employment during the same period increased only 14.28 percent. But inasmuch as employment indexes are computed on data from a number of selected plants, the Board cautions that it does not accurately measure total employment, and hence is not strictly comparable with fluctuations in total volume of production as indicated by the production index cited. Moreover, employment indexes being based on payroll data, they do not take into account part-time work, nor over-time work, indicating merely the number of employees on the payroll. However, the difference of fluctuation between volume of production and employment since 1921 is so marked, and substantiated to such an extent by the experience in individual plants, that the conclusion of a great saving in human energy in manufacturing production cannot be escaped. As the change in relative volume of employment is measured in proportion to individual plant capacity, it does not indicate increasing unemployment. It is to be interpreted rather as the opening up of opportunities to work in other fields, to the degree that the machine relieves men and women from having to earn their living with manual **labor.**

Significant in this connection is the fact that the general price level during the past five years has been declining along with greater productive activity, a symptom contrary to general previous experience, and making possible higher living standards.

While a greater output per worker employed has been made possible by modern, highly organized, high-powered and more efficient industry, it has also therewith raised the earning capacity of the individual workers. Actual wages paid per worker in all manufacturing industries combined in 1925 averaged about 114 per cent more than in 1914, and the "real" wage, that is the purchasing power of factory workers' weekly earnings, taking into account the higher price level, in 1925 averaged 28 percent more than in 1914. The tenet recently adopted by the American Federation of Labor, that the wage earner should participate in the returns for increased efficiency in the operation of the industry, in effect has been realized during the past decade.

Turn of Tide in Labor Migration

Immigration during the fiscal year 1925-26, the second year under the two per cent quota act, showed a slight increase over that of the previous year, amounting to four per cent, but partly owing to declining emigration of aliens from the United States, our net gain in population through immigration was 13 per cent greater than the year before.

A noticeable change revealed by the Board's analysis is in the migration of alien common labor. While during 1924-25, 15,106 more common laborers left the United States than entered, during the past fiscal year 43,543 entered and only 33,107 left, constituting a net gain of 10,436 for the year. Skilled labor came to the United States is greater numbers than the year before, our net gain in this class during the fiscal year being 47,147 as against 42,422 the year before. Farmers and farm laborers, however, came in smaller numbers, our net gain in this classification being 25,598 in 1925-26 as against 28,266 in 1924-25. Professional people continue to come in increasing numbers, distinctly reflecting the great economic pressure inflicted upon their class in Europe since the war. While our net gain in professional people during the fiscal year 1924-25 was 8,367, our net gain during the past fiscal year was 9,041, again showing the rising trend of the influx of professional people noticeable ever since the war.

Canada and Mexico continue to furnish the bulk of our immigration under the new restriction act, neither country being subject to quota restriction. Immigration from Mexico appears to be increasing, that from Canada declining, as far as the past two years' figures indicate.

Personal Mention

C. R. Potteiger has recently accepted the position of Sales Executive of Warren-Knight Company. He continues as Secretary of the State Board for the Registry of Professional Engineers and Land Surveyors of Pennsylvania.

James W. Cox, Jr., Consulting Engineer, 320 Broadway, New York City, makes a specialty of the solving of troubles in textile mills, the development of new types of yarns and fabrics, and the designing of fabrics of all kinds.

B. M. Horter has been appointed manager of the Cutler-Hammer Manufacturing Company's Boston office, succeeding J. M. Fernald.

In Lexington, Kentucky, on May 27th, the Unit Heater Manufacturers of the United States held a meeting, and formed the "Association of Unit Heater Manufacturers," in which sixteen manufacturers of this equipment are represented. The following officers were elected:

President—Thornton Lewis, President of the York Heating & Ventilating Corporation, Philadelphia.

Vice-President—H. S. Wheller, Vice-President of the L. J. Wing Mfg. Company, New York City.

Secretary and Treasurer—Judge Cresap, Buffalo, N. Y.

The concerns belonging to this Association manufacture unit heaters for industrial plants, which system is fast displacing the old method of direct radiation, on account of lower cost of operation and lower first cost.

Edward J. Dauner, Assistant Engineer of City Planning, in the Philadelphia Bureau of Surveys, has been promoted to a District Surveyorship.

Charles Haydock and Norman V. Bureau have organized the General Pipe Cleaning Company to engage in the business of cleaning water pipe lines in place, underground.

The pipe cleaning machines which the company will use were developed and patented by Messrs. Haydock and Bureau.

William S. Fithian is now connected with the Philadelphia Electric Company, Supply Department, in charge of the Radio Division.

C. N. Conner, formerly State Construction Engineer, North Carolina Highway Commission, and more recently Chief Engineer, Mexican National Highway Commission, has been designated chairman of the "Earth Roads Investigation" being conducted under the auspices of the Highway Research Board of the National Research Council, Washington, D. C.

Course in Steel Treating

The sixth season of the Cooperative Evening Course in Heat Treatment and Metallography of Steel, conducted under the auspices of the Philadelphia Chapter, American Society for Steel Treating, at Temple University, begins on Monday evening, Oct. 4, 1926.

The purpose of the Course is to assist those engaged in the various phases of the use and treatment of steel, to keep abreast of the rapid scientific progress which is being made in the art.

Instruction consists of a series of lectures and laboratory periods, covering the fundamental principles of the subject.

The classes include engineers, executives, salesmen, chemists, instructors, foremen, inspectors, mechanics, heat treaters and others, of widely varying occupations, age, and training.

An advanced class is available to men qualified to take up more specialized work.

The charges are nominal, the course being self sustaining, but not for profit. Descriptive booklet may be had upon application to Dean James H. Dunham, Temple University, Philadelphia.

Reduction in Lamp Prices

The great benefits to be derived from improved manufacturing methods, standardization and simplification are impressively evidenced by the lower prices for Mazda lamps.

There was recently announced a further reduction in the prices, effective September 1, 1926, amounting to about 7 per cent on the sizes of the new standard line of lamps generally used, and approximately 5 per cent on all types.

This is the eighth reduction of Mazda lamp prices since 1920. This reduction means a saving to the public of approximately $4,000,000 a year.

The prices of Mazda lamps are now 44% below the 1914 prices, although there has been a 65% increase in the average cost of commodities since that year.

American Road Builders Association—The annual Road Show and Convention will be held January 10th to 15th, 1927, in Chicago. Attendance at the above meeting will include highway authorities from all parts of North, South and Central America. Probable attendance during the full week, 35,000. The week will be known throughout America as GOOD ROADS WEEK. One feature of the meeting will be an International Day, devoted to highway problems of Latin-American countries.

The new President of the Association, H. G. Shirley, Chairman of the Virginia State Highway Commission, took office May 14, 1926, succeeding W. H. Connell, Engineering Executive of Pennsylvania.

Power Production in Industrial Plants

Discussed at a Meeting Held May 18, 1926

Engineers Club of Philadelphia

The Use and Abuse of Fuel in the Industrial Power Plant

BY F. H. DANIELS,
Worcester, Mass.

EACH year in the United States we burn about two-thirds of a billion tons of coal. This includes both bituminous and anthracite. The bituminous coal used is about 552 million tons and the anthracite about 90 million tons. Dividing this up by industries shows the following:

Industrial plants	33.5%
Railroads	25.0
Domestic	16.5
Coke production	13.0
Electric public utilities	6.5
Gas public utilities	1.0
Bunker and export coal	4.5

Possibilities for Saving

You will see from these figures that industrial plants consume one-third of all the coal mined in this country. The industrial plants use more than five times as much coal as the electric public utility plants. This means that there is at least five times the opportunity for fuel saving with the industrial plants as with the public utilities. Actually the possibilities are much greater than five to one for the following reasons. With the public utilities there is now very little waste of fuel. Coal represents more than fifty percent of their cost of doing business, and as a result the pocketbook forces them to be careful. The great majority of the public utilities have given a lot of thought and spent tremendous sums of money to assure the economical use of coal. Ten percent coal saving probably represents the maximum that can be made before the fixed charges eat up the saving.

Coal for the industrial plants is responsible for only from one to five percent of the cost of the goods made and, as a result, the boiler room is generally the last place thought of, just so long as the factory wheels are kept turning and the general manager is supplied with enough heat to keep his hands and feet warm. The average industrial plant does not recover, as useful work, more than 5% of the heat energy of the fuel used. The best plants recover about four times as much. The ordinary small industrial plant may show an average boiler efficiency of about 55%. A figure of 75% is not impossible at all and this would mean a coal saving of 25%.

This shows that the industrial plant offers about 12½ times the chance for coal saving as does the public utility. From a conservation standpoint the possibilities are enormous. 25% of the coal used for industrial plants is 53½ million tons. That is within the range of possible saving every year. The margin here is certainly large enough to justify the best thoughts and endeavors of each one of us.

Fuels Available for Philadelphia

Philadelphia is very fortunately located as to fuel supply. Fuel oil comes in by water from Texas, Mexico and Central America. It is less than one hundred miles to the anthracite fields and about twice this distance to the bituminous producing regions of Pennsylvania. You have a wide range of fuels to choose from and if you do not select the correct fuel there is no one to blame but yourself. Right now fuel oil is out of the question on account of price, except for very special applications. As a matter of fact, under any conditions, it is an economic crime to use fuel oil for steam generation in stationary boiler plants. It should be reserved for special purposes such as heat treating furnaces, where very accurate control of the heat is required, and for other uses where coal cannot be used. The question of using fuel oil is however only of academic interest at the present time. The costs under any fair basis of comparison are very much in favor of coal burning.

Of the solid fuels available to the Philadelphia district, there are anthracite, anthracite screenings, Nos. 1-2-3-4 Buckwheat, anthracite river coal, bituminous run of mine, and bituminous slack. These fuels being available, the question which you have to decide is what fuel is most economical for use in your plant, taking into consideration the size of the boilers, the type of grate, stokers or pulverized coal units in the plant, and the personnel of your boiler room.

Coal Characteristics

While the B. T. U., or heat value of coal, is the principal measure of its value, don't forget that there are many other items to be considered. The percentage of ash and sulphur, and the fusing point of the ash are most important points and, even where you buy coal in small qauntities, you should have each shipment tested for the following: B. T. U. content, fixed carbon, volatile matter, ash, moisture, sulphur, and, if clinker gives trouble, the coal should also be checked for ash fusion temperature. The coal containing the highest B. T. U. will not always work most successfully in a particular plant. Many times, where stokers are installed, a very high B. T. U. coal combined with low ash (say from 3 to 5%) may not prove nearly as economical as a coal having from 8 to 10% of ash. With a low ash fuel stoker repairs may be very high on account of not having ash enough to protect the grate surface under the high temperatures.

The bituminous coals available for the Philadelphia district and those which are most economical to buy, are in general of the low volatile and medium volatile classes. These can be obtained with an ash content of from 8 to 12% and B. T. U. ranging from 14,400 to 13,800, for the low volatile, and from 14,100 to 13,500 for the medium volatile. The majority of these coals will have a fusing point of the ash of 2500° F. or over, and this certainly will cause no trouble with excessive clinker regardless of whether you are hand firing, or whether you use stokers. Another point to be watched is to be careful not to rely on any one district, or county, as being able to supply the coal most suitable for your conditions. In any one district the coal from the different mines may vary tremendously and the only safe way to do is to have an analysis made each time you get in a new lot of fuel. The features of each particular plant have to be considered most carefully when purchasing coal. For example, if you have a large grate surface in relation to your boiler heating surface, you can run thin fires and use a coal with a low fusing temperature ash without getting into trouble, whereas, if you have a small grate surface, in relation to your boiler heating surface, and consequently are obliged to carry heavy fuel beds, the clinkers from the low fusing ash coal may cause serious trouble. If the draft available in the furnace is high you can get capacity regardless of whether you carry the fire thick or thin, and it is possible to operate as may best suit the coal you are using. If you have poor draft, you will be much more limited as to the kind of coal you can burn, taking into consideration the capacity desired. The plant that has poor draft available is at a serious disadvantage, because there will probably be only a very few coals which can be used and you will have to pay more money to get them.

Some plants burn a mixture of high volatile bituminous coal and anthracite screenings. Theoretically, this should work out well. The difficulty, however, is to get a good mixture of the two fuels. If you first feed into the furnace a lot of soft coal and then feed in a batch of anthracite you get poorer results than if you were using either fuel alone. Obtaining an intimate and accurate mixture is very difficult and in most cases is not accomplished.

When you come to the question of burning anthracite, there are several very important things to be considered. In the first place, the B. T. U. value of anthracite screenings will be at least 20% less than that of bituminous and the overall boiler efficiency, using the anthracite, will be at least 5 points less than with bituminous. This means that for the same boiler ratings you would have to burn at least 35% more anthracite screenings. Therefore, per ton, you will have to have your anthracite coal delivered to your boiler room at a cost of at least 25% less than bituminous coal. Of course, if your plant is located near the anthracite district, screenings become a greater factor in connection with steam generation. Don't forget also that with anthracite the cost of handling the coal is greater on account of the larger amount which must be burned. Also, the ash content is much higher than that of bituminous and consequently the cost of removing the ashes is greater. These factors must be considered. There is one more thing and that is quick response to sudden demands for overloads. Bituminous coal on account of the volatile matter it contains answers sudden demands for steam much more quickly than anthracite, which has low volatile and responds much more slowly to increased demands. After all, it is the pocketbook which governs and there is no way to tell which fuel to use without carefully testing and figuring which coal gives the required amount of steam at the lowest cost. Prices and conditions change from time to time and what may be right now may be altogether wrong a short time hence.

Bituminous coal landed in Philadelphia will range in cost from $4.50 to $5.50 per gross ton of 2240 lbs., No. 3 Buckwheat anthracite from $3.40 to $3.60; No. 2 Buckwheat from $4.30 to $4.40, while No. 1 Buckwheat will range from $4.60 to $5.00 per gross ton. This last size is not used much for steam generation. Most of the River anthracite for the Philadelphia district is contracted for in the Spring of the year and is dredged from the Susquehanna River, and its tributaries and creeks, in the vicinity of Harrisburg, Pa. Prices quoted at Harrisburg range from $0.90 to $1.10 per gross ton. The freight rate from Harrisburg to

Philadelphia is $2.14. This makes the cost at Philadelphia vary from about $3.00 to $3.25 per gross ton. It is quite difficult to contract with any company supplying River anthracite, due to the uncertainty of the supply. This accounts for the fact that there is not a great deal of this fuel burned in Philadelphia. In general, Philadelphia gets most of its coal from the State of Pennsylvania and very little of the high grade smokeless coal of West Virginia is brought into this locality because freight rates are higher.

Sizing of Coal

In reference to bituminous coal, stokers will, of course, handle run of mine just the same as hand fired grates. Whatever equipment you have in the way of a grate or stoker, it is better to put run of mine coal through a crusher so that it is broken down to go through a 1½" or 2" mesh. Coal that has been crushed gives a more homogeneous fuel bed resulting in a uniform resistance, through the fuel bed, to the passage of air. Crushed coal gives less chance for holes to develop in the fire, spoiling combustion conditions. Bituminous coal should also be crushed before pulverizing in order to insure a uniform feed to the pulverizing machine.

The standard anthracite sizes are given below:

No. 2 Buckwheat—all through a ⅜" and 20% through a 3/16" round mesh screen.

No. 3 Buckwheat—all through a 3/16" and 20% through a 3/32" round mesh screen.

No. 4 Buckwheat—all through a 3/32" and 20% through 3/64" round mesh screen.

River coal 15%—No. 2, 45%—No. 3, and 40%—No. 4 Buckwheat.

Suggestions for Coal Saving

Very large coal savings can be made in most industrial plants by means which do not involve the expenditure of money for any new equipment. The first thing that should be looked after is to get just as intelligent a man for boiler room foreman as possible. Intelligent operation is of more importance than anything else; this applies to the hand-fired plant with just as much force as to a plant equipped with automatic stokers, or pulverized coal.

The boiler settings should be carefully checked over periodically for air leaks. The greater the draft carried in the furnace the more important it is to look out for these leaks. A little time and some plastic cement will accomplish wonders. The results of the work can be checked very easily by either an Orsat CO_2 machine, or by the use of a thermometer for measuring uptake temperatures.

Another simple job is to find how much combustible you are losing with the ash and refuse. An occasional analysis does not cost a great deal and will tell you a lot.

You ought to go much further than this. The time has gone by when a steam pressure gauge should be considered as the only instrument necessary for the boiler room. Scales for weighing coal, and reliable meters for measuring the feed water, are essential and should be installed in every plant regardless of size. If you cannot go as far as this, at least have a set of draft gauges which will show the draft over the fire and the draft to the uptake. Better yet would be steam flow, air flow meters, such as the Bailey, which after they are once set for the correct CO_2 give a continuous guide to the air conditions in the furnace.

Improvement Due to Stokers

One question which is always in the mind of the industrial plant operator is; In how small a plant is it worth while to install stokers. In plants below about 500 boiler horsepower, it is almost impossible to save any labor, although in some cases the installation of stokers gives the fireman enough liberty so he can be employed on other duties, in addition to his work of supervising boiler operation. Usually, however, this doesn't work out. There are plenty of installations of stokers, however, in plants having a total of 100 boiler horsepower and the installation of these stokers can easily be justified under certain conditions. Suppose the installation consists of a forced draft, single retort, underfeed stoker; the rating of the boiler can be raised from banked fire to 200% of rating in a very few moments. This is done automatically, not depending upon the human element, as it is controlled by the pressure of the steam, so that the moment the pressure begins to go down, the regulating valve increases the speed of the fan engine, which, in turn, speeds the coal feed to the stoker. If the plant operates only 10 hours, it is not necessary for the fireman to come in so early in the morning to get up steam, and during the night the banking loss is cut down as compared with what would be the case if hand fired grates were used. Assuming 60% overall efficiency, which would represent good hand firing, and 70% for the stoker firing, which is very conservative, and running at an average of 125% of rating for 10 hours, 300 days a year, you have the following:

Hand firing at 60% efficiency

$$\frac{125\times4.3\times10\times300}{2000}=806\text{ tons}\times\$5=\$4030$$

Stoker firing at 70% efficiency

$$\frac{125\times3.38\times10\times300}{2000}=630\text{ tons}\times\$5=\ 3150$$

Yearly saving	$ 880
Approximate cost of installing underfeed stokers with forced draft	$2000
Return on investment........................	44%

If the plant is larger and labor saving can also be obtained, there is no doubt at all but that the stoker should be installed.

Types of Stokers

Regarding the different types of stokers, there is a natural draft overfeed suitable for boilers from 50 horsepower up to about 300. With this stoker you get away from the necessity of forced draft, but have to sacrifice quick response to overload demands. If the load is steady and high overloads are not demanded, this type of stoker is well adapted.

For boilers from 100 HP up to about 400 HP, a single, or double, retort underfeed stoker is generally used where high overloads are wanted and where quick response to overload demands is of importance. For boilers from 300 HP up to the largest boiler built, the multiple retort underfeed stoker is most desirable for burning bituminous coal.

Forced draft travelling grate stokers are the only machines which will handle special fuels such as the small sizes of anthracite, River coal and coke breeze. The travelling grate stoker has the added advantage that in addition to burning the special fuels it can handle bituminous coal. In some cases, such as a strike in the anthracite regions, this is of great importance. With proper design of arches and combustion space, efficiencies with the travelling grate stoker can be obtained about as follows:

75% for No. 1 Buckwheat
74% for No. 2 Buckwheat
72% for No. 3 Buckwheat
71% for River bottom Buckwheat
66% for No. 4 Buckwheat

Pulverized Coal Versus Stokers

The most recent addition to the line of combustion equipment is pulverized coal. There has been a great deal of interest displayed recently and an outline of the present situation might not be amiss. All pulverized coal burning equipment, and systems for burning powdered coal, fall within the following classifications:

1. The bin or storage system, otherwise known as the indirect system.

2. The unit system, otherwise known as the direct system.

The equipment used in the bin or storage system is usually about as follows:

1. Coal unloading hopper, magnetic pulley, crusher, elevators, conveyors, and bins for the raw coal.

2. Coal dryers with conveyors from the raw coal bins to the dryer. Flue gases or steam are generally the heating mediums. If flue gases are used, ducts and a fan for handling the gases are required.

3. Spouts from the dryers supply the pulverizers with dried coal. The pulverizers must have feeders, air separation fan, ducts, cyclones and pulverized coal bins.

4. An air transport system is used in most cases to convey the pulverized coal from the preparation house to the overhead storage bins in the boiler house.

5. Storage bins located above the boiler firing aisle must be provided of sufficient size to meet the plant requirements. These have to be insulated to prevent the coal from sticking due to moisture and they should be provided with automatic indicators to show when the bins are full.

6. Below the storage bins are placed the pulverized coal feeders arranged in groups for supplying the various burners.

7. Piping is necessary between the feeders and the burners as well as fans and ducts for supplying the primary air needed for the burners.

8. Usually a number of burners are used for mixing the primary air with the coal and introducing the mixture into the boiler furnace, where the rest of the air for combustion is picked up.

9. Motors or other prime movers are needed for the crusher, all the conveyors, elevators, fans, pulverizers, feeders and other mechanically operated equipment.

The equipment used with the unit or direct system is about as follows:

1. Coal unloading hopper, magnetic pulley, crusher, elevators, conveyors, and bins for the raw coal, located above the boiler firing aisle.

2. Spouts from the raw coal bins supply crushed coal to the unit pulverizers, which are provided with feeders for controlling the amount of coal going to the furnaces.

3. A small amount of piping is required between the pulverizers and the burners, the pulverizers being usually located in the firing aisle directly in front of the boilers.

4. One or more burners are used per boiler for the purpose of mixing the coal and primary air with the required amount of secondary air.

5. Motors or other prime movers are needed for the crusher, the raw coal elevators and conveyors, pulverizers and for the secondary air fans, if forced draft burners are used.

For most industrial plants the bin system is out of the question. The first cost is much higher than the unit system, ranging between $80 and $100 per rated boiler H. P. as compared with $12 to $15 for the unit system. For the existing plant it is very difficult to find the room for housing the bulky coal preparation equipment. In the case of a new industrial plant, the building cost will be increased from 15 to 20% for the bin system as compared with the unit system, on account of the space required for coal preparation.

In making the following comparison of pulverized coal and stokers, the unit system will be the only one referred to.

Comparison of Pulverized Coal Equipment and Stokers

The first cost for unit pulverized coal equipment will be about the same as for stokers; the additional cost is in the boiler furnace which must be larger than for stokers. In a plain solid wall setting for powdered coal, the extra furnace cost will be about $5 per rated boiler H. P., assuming that you set the stokers with sufficient furnace volume for best results. In either case the furnace should have air or water-cooled walls for this construction is of just as much advantage for stoker firing as for powdered coal. Under equal boiler and furnace conditions the gain in economy with pulverized coal is almost entirely due to reduced ash pit losses. The saving here is roughly two points gain in overall boiler efficiency for the coals usually burned in the East. There is not much doubt but that the operating efficiency with powdered coal can be held closer to test efficiency than can be accomplished with stokers. Operating efficiency with powdered coal should be within two points of test figures and with stokers the corresponding figure would be four points. This makes a total gain of about four points in efficiency due to pulverized coal when using eastern bituminous coal. The operating labor needed is the same in either case. Stoker maintenance of five cents per ton of coal burned represents good operation and this same figure is possible with unit pulverizers. With properly constructed powdered coal furnaces the brickwork maintenance should not be higher than with stokers. The power required to crush and convey the coal to overhead bins is of course the same with either system. The power for driving underfeed stokers is 1 KW per ton of coal handled, and some pulverizers of the unit type may average as low as 2 KW per ton of coal. The volume of air for forced draft underfeed stokers is the same as that needed for forced draft pulverized coal burners, but the pressure for the stokers is about twice that needed for the powdered coal burner. This results in roughly twice the power for supplying the air to stokers. The claim is made for powdered coal that there are no banking losses. To be sure when you bank with powdered coal you merely shut off the coal and close the boiler uptake damper, but during the bank the furnace gradually cools off and the heat which is lost from the brickwork must be replaced when you start up again. With the stoker you leave a smoldering fire which keeps the brickwork warm and less coal is needed after the bank to get the boiler on the line again. There may be some advantage in banking with powdered coal but the difference is so small as to be negligible.

Using now some of the above factors and figures let us consider the operating costs of a particular industrial boiler plant. Assume that it consists of 3—500 HP boilers, two of which are operated at 150% of rating for 10 hours a day, 300 days a year and using bituminous coal costing $5.00 per ton of 2000 lb. delivered, and containing 13,500 B. T. U.

Stokers

First cost @ $100 per rated boiler HP...$150,000	
Yearly fixed charges on cost @ 20%..........	$30,000
Coal cost @ 75% eff. $\frac{1500\times3.3\times10\times300\times5}{2000}$...........	37,150
Operating labor, firing and ash removal......	6,000
Total maintenance @ 30c per ton of coal fired.	2,229
Power to crush and convey coal, 2 KW per ton @ 1c	149
Power to drive stokers, 1 KW per ton @ 1c...	74
Forced draft, 6 KW per ton @ 1c............	446
Misc. operating costs......................	500
Total	$76,558
Cost per thousand pounds of steam...........	56.7c

Unit System Pulverized Coal

First cost @ $105 per rated boiler HP...$157,500	
Yearly fixed charges on cost @ 20%.........	$31,500
Coal cost @ 79% eff. $\frac{1500\times3.14\times10\times300\times5}{2000}$...........	35,300
Operating labor, firing and ash removal......	6,000
Total maintenance @ 30c per ton of coal fired.	2,118
Power to crush and convey coal, 2 KW per ton @ 1c	141
Power to drive pulverizers, 12KW per ton @ 1c	847
Forced draft, 3 KW per ton @ 1c............	212
Misc. operating costs......................	500
Total	$76,618
Cost per thousand pounds of steam..........	56.7c

The above indicates that the unit pulverizer may compete with stokers for the industrial plant. The costs depend on the size of the plant, the load factor assumed, and the cost of fuel. It is easy to see that if any of these factors had been more than the figures used above, the pulverized coal would have shown up more favorably. Each particular case has to be carefully analyzed on its merits. If cheap coal which could be used pulverized and which was not suitable for stokers were available, there would be no question.

Whether stokers or pulverized coal are used is not of so much importance as the question of coal conservation. The sun stored up in the ground vast stores of coal during past ages. Once used, it can never be replaced and each and every one of us should be careful in burning this coal which is the basis of our material prosperity and progress. Even if not interested in whether your great grandchildren keep warm, it is a paying investment to install coal saving equipment.

The Industrial Boiler

By. GEO. A. ORROK
Consulting Engineer, New York

IN the first place all reasonably well designed boilers, when properly operated, will give the same boiler efficiency. It makes no difference whether you buy a return tubular, a Babcock & Wilcox, a Stirling, a Heine, or any other kind of a reasonably well designed boiler, you can get about so much efficiency and you can get that efficiency on every one of those boilers. The maximum efficiency ever obtained on a boiler, with coal firing, is a fraction over 82%. Mr. Hoadley, way back in 1881, tested a return tubular boiler at the Pacific Mills and got 81 percent and a fraction boiler efficiency in a very carefully conducted test. Professor Unwin, in England, in 1880, tested a Lancashire boiler very carefully with some of that good Welsh coal that we hear about but never see, and he got 80 and a fraction per cent. Every well designed boiler that we have had has always given that and none has ever been above 82% and a fraction. With oil fuel, on the contrary, we have gone a little higher than 82% and Dr. Jacobus succeeded in getting a fraction over 83% efficiency on a Stirling Boiler in a test on the Pacific Coast. That's the best record I have of a boiler test. I don't think it's been exceeded. Suppose, we add superheaters. They may add anything from 2 to 7% to the boiler efficiency. We can put in economizers. They add something from 1 to 8%, and the maximum so far that has been obtained in any test of boiler, superheater and economizer is roughly speaking 92%, 92 and a fraction, 91 and a fraction. I don't think any of us would swear to the figure within one percent. If you add an air heater you may possibly get an additional 2% or 94% as your optimum beyond which you cannot go with ordinary methods. If you are very anxious for something nice, put in a spray in your flue, wash all the heat out of your gases, and then take the hot water and run it through a steam turbine, you may be able to save the remaining six percent of the heat of the coal and, outside of your radiation loss, you might get somewhere near 100 percent. How much you would get I don't know, but nobody has done it yet, and 92 percent, or thereabouts, represents the maximum that has been obtained, and it doesn't seem to make much difference what kind of a boiler you use for doing it. Now why is it that we can get these results when the boilers are tested by good men? The reason is that good engineers look out for all the leaks and losses and, wherever they find one, they put in a plug and stop the leak. They take care that nothing goes by and that everything goes into the boiler, and appears as heat in the steam, except what goes up the stack. That is the way to get good efficiency. The reason why the industrial plant runs from 40 to 65% in efficiency is because in the first place the owner of the plant has not been willing to pay an engineer to design it. Second, he says that a two and a half dollar a day man is just as good as a five dollar a day fireman, or, he hires an engineer at $5 or $6 a day and says he is a plenty good enough man to run that boiler plant, or steam plant, and he gets exactly what he pays for. The cheap man will waste more coal in a year than would pay a proper man's salary three or four times over. The difference between the 75% and Doctor Jacobus' results amount to a good many thousand dollars a year. The difference between 50%, which is what most of the smaller plants get, and 75%, would pay for five good men to run the plant, but the owner will not do it—that is too much money to pay for a power man. I asked a manufacturer what his power and heat was costing him. He happened to be a manufacturer of small tools. "Oh," he said, "It is very large: I must pay $60,000 a year for my power and heat." "Well," I said, "sixty thousand dollars a year, what part is that of your total outgo for the year?" He figured it up and it was three-quarters of one percent—three quarters of one percent, he paid for his power. I did the same thing for a manufacturer of automobiles. In his case it was three-eighths of one percent. I asked him how much return he was getting. He said, "Why, I am turning that over six times a year. I am getting a good return on it." If we turn over money in a power plant once in five years, we think we are doing well, and he was willing to put $500,000 in his power plant, the money to be turned over once in five years, when he could have put that money in his automobile plant and turned it over five times in one year and paid the Central Station company for his power, but that's neither here nor there. That is the economies of it.

But we were talking on boilers for industrial plants and I have said that all boilers have the same efficiency, which they do. All boilers properly run will give practically the same efficiencies, the difference being due to the carefulness of the man operating the boilers, but boilers have one other characteristic besides efficiency. That is capacity. All boilers are not alike as to capacity and as a general rule the more water contained in a boiler for a given power, the less capacity that boiler has. The boiler having the smallest water content usually has the largest capacity if it is handled well, and in industrial plants and central station plants alike we are after that combination which will give us the best efficiency with the largest capacity. When James Watt tried to improve the boiler so that he could run his engine easily, he figured that he should evaporate a cubic foot of water for every ten square feet of surface, but he found when he worked at that rating his efficiencies were quite low, so he cut the rating down, and we following him have cut it down until at the time of the Centennial Exposition (1876), it was found if a half cubic foot of water was evaporated for every ten square feet of surface, that boiler was probably at its point of best efficiency, so we called that 100 percent rating and let it go at that, and we did pretty well except that we lost sight of the capacity we got with the old boilers. Since that time we have learned better and we have been trying every year to improve the capacity, to get more water evaporated out of a square foot of surface without submitting to that loss of efficiency as you go up in the rating, that we all know so well and have tried so much to avoid. And we have done pretty well considering, the curve sloping off rather steep at first, and then more flat and finally flatter and flatter and on later installations have managed to keep the curve within a reasonable degree of flatness over a range from 75% to possibly 300 or 350% of the rating, or, in other words, from about three pounds of water evaporated per square foot, to, say, twelve pounds of water evaporated per square foot and, in fact, there are guarantees being made today that a boiler will run anywhere between 3 pounds per square foot and 15 lbs. per square foot with the boiler efficiency not below 75 percent, which is very good work indeed; or boiler and superheater efficiency not below 80 percent, or boiler superheater and economizer efficiency not below 85 percent—a very good guarantee indeed. Now how have we done this? We have done this by inceasing our furnaces, increasing our grate surfaces, burning more coal, more combustible, under the boiler, rather than by increasing the boiler's size. In the old days the boiler was about five feet in diameter and the grates were pretty nearly square, about four feet usually, and we burned about four hundred pounds of coal per hour under a boiler, that is—about one hundred pounds per front foot of boiler. We have been increasing that year by year and we thought we were doing well when we got up to 600 pounds per front foot of boiler per hour. Six hundred pounds of 75% efficiency fifty years ago was a remarkable capacity, but we have increased that until we are burning 1200 to 1500 pounds per hour per front foot at efficiencies above 80 percent for boiler and superheater, and we have sometimes gone as high as 2200 pounds per front foot of boiler but that has been at the expense of efficiency.

With oil, however, we have gone up to higher rates and the best that I have seen recorded with oil is 3000 pounds of oil per hour from one burner in what was the equivalent of a 36-inch combustion chamber, 7 feet long. In that case no bit of flame went out of the seven foot chambers. Sometimes two rows of oil burners are used so you see it would be a simple thing to get 2500 pounds of oil burned per front foot of surface, which is the equivalent of about 3200 pounds of coal. That has been done in some marine boilers for express purposes, but in this case the efficiency went down even below the 75 percent mark.

Record of Meeting will be continued in October issue

Landmarks in the History of Prime Movers*

By H. W. DICKINSON, M.I.Mech.E.

It is not the author's purpose to give a complete history of the development of Prime Movers. He wishes rather to pick out the outstanding inventions or turning points in ideas that have led to such developments. Please bear in mind always that just as *natura . . . non facit saltum,* so inventions and ideas, although they advance apparently by jumps, are nevertheless the result of long previous excogitation.

To begin with we must designate as the first prime movers, man and the animals that he domesticated. Perhaps some one will tell the author whether they can be classed as heat engines, and if so how to explain their efficiency which should be very low theoretically as their limits of temperature are extremely small. Domestication of animals and slavery of his fellow man, much as the author regrets to have to say it, must be regarded as the first landmark. A servile state released the free man from the necessity of performing the more arduous tasks and permitted that leisure which enabled the few to prosecute the arts. Before any serious advance could take place, a long period had to elapse during which the concept of the mechanical powers and the idea of rotative motion (for nothing analogous existed on our earth) had their rise. These advances were probably the outcome in warm eastern countries of simple requirements such as the erection of buildings and the raising of water for irrigation.

The energy of flowing water had naturally been commonly experienced for thousands of years before it was harnessed as a prime mover in the form of the simple current or float wheel dipping into a stream.

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*An address delivered May 3, 1926, before the Society of Engineers, at the Science Museum, London, England.

We first know with certainty of its being used during the first century B. C. in the Mediterranean area. Besides raising water, this wheel also replaced hand-labor in grinding corn. From this the development of the water-wheel using the weight as well as the momentum of the water was only a matter of time. It might be observed that the period of greatest advance in its efficiency was at the beginning of the 19th century when enormous water-wheels like that of Laxey, I.O.M., 70 feet diam., were erected, and new types like the Poncelet were invented.

The energy of the wind must have been experienced if anything more frequently than that of water, yet it was centuries later than the water-wheel, if we except the sailing vessel, before it was brought into the service of man. It was natural that this should be so because wind is inconstant and is of small power, so that the inventive and constructive skill needed to bring it under control was of a high order. The post mill in the simplest form appears in Western Europe in the 12th century. It is thought to have come from the East, but whether it spread across Europe or whether the knowledge was brought in through the Arabs of Spain we are ignorant. The post mill had a vertical fixed post on which were grouped the wind shaft with its sails and the transmission to a pair of mill stones—for its duty was practically always that of grinding corn. To get increased power meant longer sweeps and these again meant greater height. This led to the smock mill in which only the top and not the whole mill is turned into the wind. Reefing sails and the fantail for turning the mill automatically into the wind followed at the end of the 18th century. It is safe to say that nothing fundamental in the use of wind power except perhaps the Flettner rotor has since appeared.

Let us now revert mentally for a moment to the Middle Ages and consider the line of thought likely to have been followed by a speculative mind, nourished on the time-honored Greek idea of the four elements—earth, air, fire and water, and starting from the fact that air and water having been, as we have seen above, successfully harnessed, there remained earth and fire to be subdued. But in what direction was a solution to be found? Since the discovery of fire, fuel had been burnt for cooking, warmth and, as time went on, for industrial purposes; fuel had been used to heat air and liquids, and if done in closed vessels it was known that striking effects could be obtained. The writings of Hero, of Alexander, shows that they were used to mystify the credulous in classical times. The fact is that the task was one of enormous difficulty because, unlike the case of wind and water, *molecular* changes were involved. Hence, a long period had to elapse to enable considerable advances in knowledge to be made before any forward step could be visualized. Such were the studies of the philosophers, Galileo and Torricelli in the 17th century, who showed that the atmosphere had weight and explained the fact, then well known, that a pump will not suck water beyond about 28 feet in depth.

Thomas Savery, F.R.S., the most prolific inventor of his day, in 1698 patented his "fire engine" in which he embodied two ideas: one was to condense steam in a vessel communicating with water, when the latter would rise and could be retained by a non-return valve; the other was to force up this water by the direct pressure of steam on its surface. The operations could be repeated indefinitely by working suitable valves, for it will be observed that the ideas involved are those of the pulsometer of today. Alas for Savery, the mechanics of his day—the blacksmith, plumber and carpenter—were not equal to the task of making vessels that would stand the considerable pressures involved. His engine was nearly 200 years before its time!

Meanwhile, Thomas Newcomen had succeeded by 1712 in perfecting the "atmospheric" engine which is the progenitor of the modern steam engine. Without doubt, Newcomen's engine is a landmark of the first order in the field that we are investigating. Newcomen adopted the cylinder and piston; he hit upon the idea of condensing steam under the piston; he schemed a way of getting rid of the condensed water and entrained air; he connected the piston rod by a chain to a giant pump handle or lever, on which the pump rods were hung; and finally he made the engine repeat its movements automatically. The great point to be observed is that no pressure higher than that of the atmosphere had to be provided for; hence the construction was within the capabilities of the mechanics of the time. This is a condition, be it observed, that limits invention all through technical history.

The atmospheric engine held sway for half a century till James Watt in 1763 had the brilliant inspiration of condensing the steam in a vessel separate from the cylinder. This is another outstanding landmark, for at one bound the fuel consumption was halved.

Twelve years of experiment and disappointment elapsed before Watt was able to join the "princely" Matthew Boulton in the celebrated partnership which gave Watt the opportunity and time to bring the engine into public use.

Watt's next step was to employ his engine for obtaining rotative motion. Debarred by a patent from using the crank and connecting rod, he invented several substitutes and one—the sun and planet gear—was used till the expiration of the patent. He doubled the power of the engine by making it double acting; this necessitated a positive connection, instead of the chain, between the piston rod and the beam, but he completely solved this difficulty by his invention of the parallel motion in 1784. Henceforward the engine ceased to be merely an apparatus for raising water and entered upon the world-wide sphere of a universal stationary engine—the greatest landmark of all in the history of prime movers.

The engine was still a vacuum apparatus, however, till in 1802 Richard Trevithick, the great Cornishman, patented the high pressure engine, *i. e.* he used steam at a pressure above atmospheric and dispensed with the vacuum. The simplification that resulted made possible a compact self-contained and cheap motor that could be adapted to practically any purpose. No one was quicker to see this than the inventor himself, and in 1803 he applied the engine to locomotive purposes. This experiment inaugurated the era of mechanical land transport by road and rail —a subject to which it is impossible to do justice within the limits of this paper.

We must now pause to glance at what was being done with water power, for as remarked above, no fundamental improvement took place in wind-mills. The crude and efficient Barker's mill or reaction wheel was developed by Benôit Fourneyron in 1827 into the pressure turbine in which multiple fixed curved vanes direct the water on to corresponding moving vanes which so change the direction of motion of the water that its energy is absorbed. This was a landmark of the first magnitude in that it has opened out the vast field for experiment and research in utilizing falls above the limits of a water wheel. The continued advance in size and in closeness of speed regulation has been very marked and turbines of 50,000 h. p. are now common.

A parallel development is afforded by the case of the simple impulse wheel provided with buckets on its periphery on which impinge one or more jets of water at high pressure. Dividing the bucket to split the jet, the invention of Mr. L. A. Pelton in 1878, greatly increased the efficiency; hence his name is usually associated with the motor. Governing has since been the great problem, but so successfully has it been done that such wheels are used for the most exacting service.

Harking back to the heat engine, the landmark that we have to note next is the introduction by N. A. Otto in 1866 of the compression gas engine, the culmination of the labors of inventors over a period of 70 years. This opened out a great field of activity not only in scheming different cycles of operation and regulating the mixture of gas and oil, but also in the use of other fuels for combustion, such as high flash oil and petrol for engines. This introduced a further complication—viz., the necessity of gasifying or vaporizing the fuel before combustion. The hot bulb for oil and the carburetter in its innumerable forms for petrol have been the means adopted to this end. Still another device is that of spraying the fuel—crude oil—into pure air at the end of the compression stroke, as patented by Akroyd Stuart in 1890 and Rudolf Diesel in 1892, whence much development has taken place.

The coming of the gas engine and its rapid development seemed as if it was going to elbow out the steam engine; in fact Sir Frederick Bramwell at the British Association in 1881 said: "However much we may today contemplate with regret even the most distant prospect of the steam engine becoming a thing of the past, I very much doubt whether those who meet here fifty years hence will then speak of that motor except in the character of a curiosity to be found in a museum." Within three short years of this prophecy, however, the steam turbine was brought out by the Hon. Sir Charles Parsons, who thus set up another landmark in the history that we are tracing. The steam acts, not by pressure as in the reciprocating engine, but by change of momentum, and it is evident that, just as in the case of the water turbine, there must be two general types, viz., the reaction and the impulse turbines. The Parsons turbine is of the former type, while the impulse turbine is due to the labors of Dr. C. G. P. de Laval of Sweden in 1889. The turning point in the progress of the steam turbine was reached by Parsons in 1891, when by making it condensing it equalled in efficiency, and later with larger units, surpassed the reciprocating engine.

There have been many turbines brought out since, under different names, but critically examined they will be found to belong either to one or the other type, or to be a combination of both. One of these, however, must be mentioned—that of Birger Ljungström, 1906, who has two sets of blades running in opposite directions and takes off power from both shafts; needless to say great practical difficulties had to be overcome to accomplish this. The rapid increase within the last decade in the size of units, accompanied by marked reduction in weight for unit power and the recent great increase in boiler pressures that have taken place tempts us to state that here is another landmark.

Yet after all that has been done, we are faced with the fact we only have been able to obtain a thermal efficiency of less than 40 per cent, and that each successive per cent has meant much greater effort than the last. We feel that we have nothing to boast about, rather the reverse, so that it is small wonder that many eyes are turned towards a new source of power of which we have the first inkling, that of the energy of the atom.

Aero-Transportation

A Discussion Held March 16, 1926, Under the Auspices of

The Engineers Club of Philadelphia

(*Continued from page 190 of the July issue*)

Regulation of Air Transport

BY WILLIAM P. MacCRACKEN, Jr.,
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THERE has been a great deal said, both pro and con, on the subject which has been assigned to me, but as a matter of fact my first experience with this particular subject was not as a member of the legal profession, but rather as a flying cadet during the days of the War. It was a result of my experience with regulations which were not uniform at the various flying fields, with regulations which were constantly changing, which were inconsistent, which got a good many of the fellows into trouble, that I formed my first impressions as to what was necessary and what was bound to come as far as the regulation of commercial air transport was concerned. However, I left most of those ideas down in Texas when I got my discharge and went back home, and it was not until a couple of years later, when in St. Louis at the time of the meeting of the American Bar Association, that I listened to a discussion upon this subject by some of the members of that Association. As a result of that discussion, the Conference of Commissioners on Uniform State Laws appointed a Committee and assigned to that Committee the task of drafting a uniform State regulatory aviation law.

I had had some experience with uniform state laws. They have done a great deal to simplify the commercial problems of the United States, but they are not what their name implies. First of all, you cannot get the Legislatures in all the States to adopt them. If you could get them all to adopt them, they would not adopt them exactly as presented by the Commissioners. Some particular States want to change this provision, and some another. But, aside from all that, the thing that makes uniform State regulation of aeronautics impossible is the fact that aviation is so constantly changing by reason of the work that men of the engineering profession are doing. Aeronautical development makes the regulation of today obsolete tomorrow. You cannot expect the Commissions in the different States, even though you had a uniform law, to adopt uniform regulations. For that reason, it occurred to me that the logical place to vest the regulatory power over aeronautics was in the Federal Government, rather than in the forty-eight different States. After talking with some of my older friends, they raised my courage to the point where I put the proposition up to the Executive Committee of the Association, with the result that for the past six years there has been a Committee of the American Bar Association at work on this particular subject.

The Chairman, as is often the case in a gathering like this, did something that we are all quite accustomed to in the legal profession, namely, made some rather disparaging remarks about the way we handle your business. On the other hand, it occurs to me that it is the complications of our modern civilization, which have been brought about by the engineering profession, that make it necessary for the lawyers to straighten out your tangles and if you are only half as thankful for the jobs that we do as we are for the jobs you have done, we will get along with mutual happiness and satisfaction.

In Philadelphia was drafted the greatest covenant of Government that has ever been promulgated. The spirit that dominated the Constitutional Convention which drafted the Constitution of the United States is still being kept alive and broadcast throughout the world, particularly throughout the United States. Consider the changes that have taken place in a little less than 150 years since that document was drafted. Our methods of transportation were then confined to the sailing vessel, the horse-drawn vehicle and the man on foot. Our buildings were but one and two stories high; our means of communication were solely by the power of man's voice and the transmission of a letter on horse back. We had none of the forms of amusement, none of the means of carrying on commerce, nor the complicated manufacturing industry, that has grown up and developed in this country during that brief period and yet that constitution is the keystone of the Government of 110,000,000 people scattered from coast to coast. You can stand in Philadelphia and make your voice audible to the people on the Pacific Coast. You can hear their voices answering you. You can now send your letters to California in less time than it then took to send them from Philadelphia to New York. When you consider that this great development has all been brought about under a system of government which was conceived, and has in a large part been preserved, by the legal profession and the Supreme Court of the United States, I say that you are justified in believing that we can draft a code of air regulation that will apply not to one State alone, but to the entire United States.

If there is anything that is inter-state outside of radio, it certainly is aviation. It knows no state lines. In flying above the clouds, as a great deal of the flying is done, you do not know what State you are over. It is not one of those functions which properly belongs to local government. No one believes more in personal liberty and in local self-government than I do. On the other hand, I realize that there are certain problems which can not be dealt with locally and which must be dealt with by the Federal Government. I believe that in handling a great aeronautical transportation system such as has already been started, we must have regulation, and uniformity of regulation. The people are going to demand it for their own safety. A great many of the operators themselves already want it. Why? There are two reasons. First of all, it helps to gain the public confidence, and that is something that is needed. In the second place, it protects them in their operations from the man who is incompetent and who does not have a safe aircraft in which to fly. It is perfectly true that the air is not crowded at the present time, but all of the operations are not in the air. Every plane that goes into the air must, at some place or other, find a place to alight, and naturally they are all most likely to alight on municipal landing fields. When a pilot lands, if he is not a competent pilot and not in an air-worthy machine, he represents a potential danger against which others must be protected.

Sir Sefton Brancker* pointed out that we have done almost everything the opposite from the way they have done it in England, and I hope we can learn by their experience, as they apparently are learning by ours, and if we do, as I believe we will, our regulations are not going to be onerous, nor will they tend to put out of business the men who have been carrying on the commercial service that this country is so justly proud of.

It is fully possible, not only posible but probable, that the regulations which are put into force by the Federal Government will not do any harm. We have seen the harm that too strict regulation has done for commercial air transport in Europe, and we certainly will not, with our eyes wide open, repeat those mistakes. The question will be, Will this regulation do any harm? If it will, then we won't adopt it. If it may do some good, then we must try it. That is the way we should go about it in the first instance. It is the way I believe we will. But of one thing I am confident, and that is that if we have 49 different sets of regulations, as we are bound to have if the Federal Government does not take jurisdiction over all flying, we are going to have endless chaos.

Let me point out just one example of it that occurred recently. You are familiar, more or less, with the State of Florida. It has the reputation of being very lenient, particularly on matters of taxation, and on things to attract commerce and the people of the north. Florida enacted, in the last few months, an aviation bill. It provides among other things that the State license number should be painted on the fusilage of the ship in letters three feet high. Now that would bar over 90 per cent of the airplanes that are in commercial air service today, from appearing in the State of Florida. In Illinois the State legislature came within a very close margin of adopting a law which would have required compulsory insurance of a kind which no insurance company was then writing, except at premiums which were so high as to be prohibitive. There would not be a single operator able to operate in Illinois today, had that law gone on the books. Some of our Illinois statesmen did not realize that situation, they thought they would rather have State regulation than Federal regulation, because Springfield is closer to Chicago than Washington. It is a short-sighted view and I think if we are going to preserve the advantages that we have in great distances without conflict of jurisdiction, we must look to the Federal Government to provide regulations. We must also see to it, certainly in the days while this child is still an infant, that it gets its regulatory medicine in homeopathic doses.

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*See Engineers and Engineering, July, 1926, page 185.

The Department of Commerce and Aviation

BY J. WALTER DRAKE,
Asst. Secretary of Commerce, Washington, D. C.

IN connection with civil aviation I have great regret that I am neither an engineer nor an aviator. Upon this subject, which has occupied much of my time for many months, the Department of Commerce has been pressed to answer various questions in view of the possibility that it would be called upon to administer regulatory laws. And among the persistent questions relating to this subject are those with reference to the kind of regulation that would take place under such law if it is enacted.

It will appear to you, I am sure, that it is both inexpedient and impossible to make definite statements or promises outlining the policy of the Department of Commerce with respect to the regulation of civil aviation until we know under what sort of law we have to proceed. However, I believe there are certain observations that may be made which will ease the minds of many who are concerned with the subject of regulations and make clear the attitude of the Department.

You have heard through all the interesting discourses a strain of acknowledgment that there is a fear on the part of the public towards the use of aerial transportation. That is a very natural state of mind. It is attached not only to air transportation but personally I have had experience with it in the use of the automobile. The same fear existed when the steam engine and the steamboat were first introduced.

There is no doubt in my mind but that aerial tansportation is on the eve of great development, and I am equally assured that, with proper care and attention to its development, a great deal of the distrust that may exist can be dissipated. One of the most important steps that is required to that end is that there should be legislation enacted, authorizing some branch of the government to administer proper laws, for its control and regulation. It is essential that this be done so that the government can say to the people of this country, "We have examined and inspected this aircraft; we have examined the pilot; and we think, so far as it is humanly possible to ascertain, that the craft is safe and the man is qualified to navigate it." This procedure would do much to quiet the public mind on the subject of the safety of aerial transportation. There have been many attempts to secure such legislation for the regulation of air traffic, for the inspection of planes and the licensing of pilots. The gentleman who has preceded me (Mr. MacCracken) has done splendid work in endeavoring to secure a good comprehensive law to that end.

There is a bill pending in the House of Representatives at the present time and there is also pending in the Senate a similar bill but much more limited in scope. This legislation proposes to authorize the Department of Commerce to perform necessary functions in connection with the licensing of pilots, examination of airplanes, establishment of airways, furnishing aids for aerial navigation, and other essential services very similar to those now rendered by the government to the merchant marine. The aviation world has been urging such action and to a considerable extent the development of civil aviation has been retarded because of the absence of such authority in a responsible government agency.

The question that is put to us in the Department of Commerce is, "If such a law is enacted what kind of regulation will you give us." That is an all-important question with many of those who have been devoting themselves to the development of civil aviation. Back of the question lies what appears to them to be a well-grounded fear that there will be over-regulation, so-called. I do not question the sincerity of those who feel disturbed on this point, and are pressing the Department for an answer to the question. Many of them have devoted themselves wholeheartedly to civil aviation and its development as a national enterprise. I have great admiration for men who have pioneered in this great epoch-making movement, as I know many of them have, at considerable expense of their own money and with no hope of reward other than to make available to this country a new and wonderful means of fast transportation. And I have no patience with those petty souls who are continually attacking men who do that sort of pioneering for their country.

It is not a difficult matter to answer this question. If the proposed law is enacted and the Department of Commerce is authorized to set up and enforce regulations, set up navigational aids, and do those other things I have described for civil aviation, the Department proposes to adopt the same attitude and the same policy which it has already followed in relation to the whole industrial world. That policy is an open book. It has been one of the most outstanding examples demonstrating what fine results may be obtained through a full and cordial cooperation between the government institutions and business. So that when I am asked how the law as to the regulation of aerial transportation will be administered, I repeat as I have said above , that the Department of Commerce cannot pledge itself to any definite form or extent of regulation but it can and does pledge that it will call into conference the best minds and the best experts on this subject in the country, and with their aid will solve the whole problem as it has endeavored to and has succeeded in solving other industrial problems.

There are many men in this room and many scattered throughout the country who are eminently able and willing to come to the aid of the Department and assist in every way in devising regulations and giving them effect to accomplish the things that are required. The first and primary object of regulation of every kind which deals with questions of human life is to ensure safety of life. The second object is to aid those who are interested in such form and manner as will best serve to promote their enterprise and serve their own and the public interest. Therefore, with the help of such assistance as I have indicated, the Department of Commerce will proceed to establish such regulations and adopt a policy of administration thereof as will, first, effectively safeguard human life; and next, and at the same time, will contribute to the encouragement and promotion of the development of civil aviation. We have continually relied upon expert advice in this and all other subjects, and we propose to do so in this instance. Obviously, the purpose may best be accomplished by proceeding along the line of constructive action and not in the direction of destructive action. I do not think it is necessary to say more. Certainly we in the Department of Commerce will not be called upon in sober thought, by those who have this great project at heart, to go any farther than I have outlined. If that program is carried out, we are bound to amply meet the necessities of the case and every one will be assured of full and fair consideration; anything more than this would be impossible to promise.

With reference to the legislation referred to there is another observation which is extremely pertinent. There is very little perfect legislation, in fact no perfect legislation, enacted. In such a case as this it is obviously necessary to feel our way along. Last year, it is true, we had what we thought was a complete, extensive and embracing bill which covered the subject satisfactorily. The legislation now proposed is much shorter. It leaves out some measures that we may consider essential, but it is a beginning and no doubt a good beginning. We need legislation and we need it now; and while this bill does not go as far as some of us think it should go, I do not think that we can, by any manner of means, afford to wait another year for legislation which will authorize some responsible federal agency to undertake the vitally necessary functions required for the development of civil air navigation. It therefore appears to me to be the part of wisdom that we should endeavor to secure something in the way of a civil aeronautics law even if it is much shorter and much less extensive than we need. Let us get it this year. Let us be sure that we get started without further delay. All over the land we see great developments in civil air navigation. Lines are springing up financed by responsible people taking on the business of our air mail and beginning to build up business as common carriers. They are greatly impeded by the lack of just such a law as we have discussed. The longer such legislation is delayed, the more difficult and complex the situation will become. If we take such a law as we can now get from Congress and proceed under it, experience may well be gained which will light the way for a further extension or modification to suit conditions as they may develop.

So far as the Department of Commerce is concerned, as in all other cases, we are here to serve you. In order to make our services more effective and helpful, we need your cooperation and we intend to call upon you for it when the time comes. We have continually called upon the great engineering fraternity in this country, and we have not looked in vain in the past for wise and constructive help. My distinguished chief in the Department of Commerce is an engineer and an honorary member of this Club, and he has brought the engineering fraternity close to the Department. In this very case of civil aviation we have called upon the engineers of the country to step in and help. They responded by not only giving their time and best effort, but they paid the bill. That has happened in a great many other cases. We therefore have a very kindly feeling for the engineers. We acknowledge their very fine, patriotic help and leadership, which has done so much for all the great enterprises that are the ground work of this country's industrialism.

Conservation of Power in Industrial Plants

Discussed February 16, 1926, at a Meeting of

The Engineers Club of Philadelphia

(*Continued from page 218 of the August issue*)

Economic Factors Governing the Purchase or Generation of Power

By W. A. SHOUDY
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THE daily papers recently quoted Mr. Owen D. Young as saying, "When we find a high wage level there will we find an abundance of cheap power." Although Mr. Young was speaking specifically of purchasable power his remark applies equally well to that generated in the isolated plant. Cheap power resources mean large production per man which in turn means an increasing wage level without an increase in production cost. This fact is clearly shown by the United States census reports and has been long recognized by the proponents of mass production. Today the leaders of labor are insisting that the increase in wages must come by increased production per man. Much of this increased production will come through improved methods, the elimination of lost effort and by closer cooperation between employer and employee, but a still greater increase will come through the substitution of mechanical for muscular power.

The public utilities are fully alive to this condition for it is their business to sell power and, as good salesmen, they are showing the industrial manager how electricity can be substituted for muscle and unit costs reduced by increasing the output per man. The whole superpower movement is an attempt not only to reduce fuel consumption, but to generate a larger kilowatt hour output per employe.

"Before the War" and After.

In the years prior to the World War the power salesman's task was not an easy one. Fuel and labor costs were low and a well designed small factory power plant would often generate power at a cost very close to that of the local central station, making a sale impossible if the utility were allowed even a small profit. Today conditions are reversed: fuel and labor rates have nearly doubled, the size of generating units required by the factory has not greatly increased, no great improvements in economy have been developed and the cost of equipment has increased—the whole resulting in a large increase in both production costs and fixed charges.

Few utilities were able to increase their generating capacities during the war, except when such increased capacity could be allocated to war industries. On the resumption of normal conditions, the utilities were, therefore, so short of capacity that they could quickly find business for very large new generating units. These larger units not only effected a large saving in operating labor but also made possible refinement of design and justified the inclusion of auxiliary apparatus resulting in large reduction of fuel. The cost of production in central stations has gone down with great rapidity during the past few years. Labor costs per kilowatt hour have been reduced in almost an inverse ratio to the size of the generating unit and, in the last five years, the annual kilowatt hour output has doubled without increasing the consumption of fuel. In other words we are generating twice as many kilowatt hours per lb. of coal as we did five years ago.

Were it not for the fact that generating costs are only a part of the cost of producing central station power, there would be very few factory power plants that could be justified. As the situation stands today the question before the factory management is not "Can we afford to *purchase* power" but "Can we afford to *generate* power in our own plant."

How to Find Out

This question is not readily answerable nor is it possible to lay down any formula applicable to every problem. There are some general classifications that can be made but, when the right classification is found, it merely tells us whether we can arrive at our answer by rule of thumb or whether an elaborate engineering survey will be necessary before an answer can be found. An isolated plant is built for one of two reasons: Either (1) because satisfactory service cannot be obtained from a local utility or (2) because power can be generated at a total cost less than the estimated bill of the local utility. Either of these reasons may be the deciding reason.

The first is generally the easier to discuss and settle. Unsatisfactory service may mean too many interruptions, irregular voltage or frequency, or lack of central station capacity. It is a question that must be answered by the utility, for the correction lies entirely within the control of the utility management. Satisfactory service can generally be obtained today from the public utility except in some of the remote districts, but if such service cannot be obtained, the plant owner must build his own plant, regardless of the cost of generating power. His problem becomes that of designing the most efficient plant that the prevailing fuel and labor rate can justify.

When the problem becomes that of comparing the cost of private with purchased power, the following items must be considered:

1. Annual use factor (and, at times, load factor).
2. Fixed charges:
    a. Interest on investment,
    b. Depreciation (including amortization, etc.),
    c. Insurance,
    d. Rental,
    e. Taxes.
3. Operating costs;
    a. Labor,
    6. Repairs and Maintenance,
    c. Miscellaneous,
    d. Fuel,

All these items must be considered before an intelligent answer can be expected. They are not arbitrary items set up to keep the accounting department busy; they are charges that must be met and, although in the smaller plant several items may be grouped together to save bookkeeping, they must be considered in the estimate.

USE FACTOR AND LOAD FACTOR, (1). The hours of useful work obtained from the plant has a decided bearing on the cost of operation affecting both fixed charges and the cost of maintenance or repairs but in opposite directions. The ratio of the average load (for 8,760 hrs.) to the capacity of the plant is the annual use (or capacity) factor. The higher this factor is, the lower will be the fixed charges per kilowatt-hour, or horsepower-hour, because these charges will be spread over a larger output. The cost of repairs however will increase with an increase of use-factor because the equipment is driven harder and longer and, at times, repairs must be made at overtime rates and sometimes without time for a thorough and lasting job. This term use-factor should not be confused with load-factor for the latter is the ratio of the average load (for 8,760 hrs.) to the maximum load experienced during the year. Both these factors may be numerically the same, as when the peak load is equal to the capacity of the plant. The use-factor however may be 50% when the load-factor is 100% but the load-factor cannot be higher than the use-factor. We use the terms "load-factor" in figuring the central station bill but "use-factor" when figuring fixed charges per kilowatt-hour.

The possibility of misunderstanding arising through the wrong use of these terms can be illustrated as follows. A factory requires a total of 900 KW at a 40% annual load-factor. If power is purchased 3,153,600 KW Hrs. will be paid for with a 900 KW demand charge. This relatively high load-factor indicates that the plant operates for the major part of the year. If continuity of service is necessary, spare equipment must be installed and the generating units will probably be three of 500 KW capacity. The average load will be 360 KW, the capacity 1500 KW and the use-factor the quotient, or 24%. Should the estimated peak actually prove to be 800 KW, the load-factor would be improved and the cost of purchased power per kilowatt-hour lowered slightly but the cost of generated power would increase. If only 1000 KW is installed this illustration is still appropriate but to a lesser degree. An estimate of purchased power on the basis of use-factor would give too high a cost, an estimate of private power on the basis of load-factor will give too low a cost.

FIXED CHARGES, (2). Except in organizations where a definite system of accounts covering fixed charges is obligatory, there seems to be more opportunity for going astray than in any other part of our estimate. State commissions have laid down rules for utility accounting and, although there are differences in definition of terms, these are unimportant so long as the definitions are understood. Other industries do not have a uniform classification; hence it is impossible to discuss the terms without an extensive set of definitions. All the items of these charges are in percentages of the capital investment and continue, whether or not the plant is operated, until the capital is written off the books. A complete discussion of this subject is obviously impossible but some comment is pertinent.

INTEREST ON INVESTMENT, (2a). This item is generally the rate paid for money. If we must borrow, the rate is easily determined but, if taken from surplus, we must use the rate this would earn if left in the surplus. If it is necessary to take the money from working capital, the rate of interest may be very high.

DEPRECIATION, ETC., (2b). Much has been written on this subject but, for the purposes of this paper, we may use the inaccurate definition of "that annual deposit in the bank which will give us back our capital when our plant is no longer of use." On the basis of such a loose definition, we must estimate the years of life we may expect from the apparatus and, when possible, when it will become inadequate for our needs. Such estimates are always inaccurate and must therefore be left to the business judgment of the management. Differences of opinion on this item may sometimes sway the choice between purchased or generated power.

TAXES, (2e), INSURANCE (2c), RENTAL, (2d). These items are determined by local conditions. Insurance and taxes are easily determined but rental is often lost sight of. The installation of equipment in a vacant building does not mean that the building is obtained for no cost. If the equipment is not installed the building should be sold or rented; to use it for power means that rent is lost unless charged to power. A fair rental should be charged even if only a nominal amount can be justified.

OPERATING COSTS, (3). A more detailed subdivision of operating costs should generally be used, particularly after the plant has begun operation. Such detailed costs are of great help in improving plant operation but, for advance estimates, the briefer classification is generally sufficient.

OPERATING LABOR, (3a). This item should include all labor on the regular operating payroll, both skilled and unskilled, necessary for the continuous operation of the plant. It should also include such labor as is necessary for cleaning and the occasional labor necessary for unusual coal or ash handling conditions. Supervision should not be forgotten and a portion of the plant office cost should be borne by power. The exact proportion is difficult to estimate but an effort should be made to apportion it in accordance with the amount of time the plant office gives to power supervision.

REPAIRS AND MAINTENANCE, (3b), are always difficult to estimate and, at best, are seldom better than educated guesses. So much depends upon the type of service, the quality of apparatus and the intelligence of the labor and supervision. Repairs in a new plant should be low but inspection and maintenance should be begun at once or heavy repairs will be experienced after a few years operation. The mistaken policy of delaying maintenance often results in such heavy repairs in later years that the cost of private power becomes greater than that of purchased power. This item in the estimate should include the cost of regular inspection, and the repairs should be estimated for at least five years and preferably for the life of the plant.

MISCELLANEOUS, (3c). This item is also determined by an intelligent guess. It is a minor one, including lubrication, waste and sundries, but it can become a large cost, if economy is not practiced during operation.

These three divisions of the operating costs—Repairs, Maintenance and Miscellaneous—are a relatively small part of the cost of operation of a large plant but their importance increases as the size of the plant decreases, almost in an inverse ratio to the plant capacity. The "intelligent guesses" are sufficiently accurate in estimates for a large plant but the estimate should be made with great accuracy when a small plant is under consideration. In the writer's opinion, because of this liability to error, there should always be an appreciable margin of saving in favor of private power over purchased before a decision to generate is made.

FUEL, (3d). There is usually closer agreement in estimates of fuel consumption than in any other item. This is because we are dealing with factors that can be accurately calculated and about which much has been published. There is, however, one indeterminate factor, that is, the human factor in operation. The science of psychology has not advanced sufficiently to make it possible for us to prophecy what this factor will be. Mr. David Moffet Myers pointed out some years ago that the efficiency of any plant is the product of the efficiency of the machinery and the efficiency of the man running it. We can calculate the first; we can determine banking losses and fuel for starting but we must divide the fuel rate by a factor *less* than one before we can tell the average fuel rate over a long period of time.

We have known for many years that the average fuel consumption is always greater than that obtained under test conditions. We have blamed banking periods and load factor but the truth is that neither of these items explains the difference. The writer has tried to determine at least a range within which the human factor might lie, both in industrial plants and central stations, but without success. During the last few years he has studied this subject in a central station with but few generating units; an ideal laboratory. This study consisted in calculating the fuel rates for each load based upon the test performance of each piece of apparatus. These rates were used to determine the minimum fuel consumption for each hour for various periods, some as long as thirty days. The coal for banking and starting up was determined as well as the influence of varying loads and other factors but there was always at least a small margin of unexplained losses. This margin varied with the man operating the plant and also with the weather or other conditions that tend to affect the operator vitally. The Rankin efficiency ratio rates the skill of the turbine designer; some day we will have an "operating efficiency ratio" which will rate the skill, or human factor, of the plant operator.

The result of this search for the human factor has convinced the writer of just one thing. He can estimate the fuel consumption of a plant that *he* will operate, but if another is to operate it his estimate may be either high or low.

It is for this reason that such bitter arguments often occur over an estimate of future power costs. Such discussions could often be avoided if the theoretical fuel rate were first calculated and this multiplied by a fraction representing the human factor; this factor could be discussed less heatedly and an agreement reached.

The public utility has other costs besides operating charges that must be met and it must make a profit or go out of business. If it were not for this, no industrial plant could compete with the modern central station because of the greater efficiencies possible with the larger central station equipment, unless the industrial power were a by-product. If power requirements are large, operating costs other than fuel are relatively low and, under such conditions, a condensing factory plant is frequently justified. Such a set of conditions is not frequently met and the small isolated generating plant is seldom justified. No set rule can be laid down for this class. The answer can only be determined by an analysis along the lines suggested above.

By-Product Power:

Substantially all factories have some need of steam for heating or processes. Even the smallest requires building heating. The latent heat is a large proportion of the heat developed in the boiler. It cannot be used for power but can be used for heating. In the majority of cases, the factory plant is justified only when this latent heat in the exhaust steam is utilized. The power then becomes a by-product and is obtained at low cost.

The use of low pressure exhaust steam for heating has been the practice for many years but low back pressure is not necessary. One American rubber factory has for a number of years been operating a 5,000 KW turbine exhausting at 80 lbs. gauge and using the exhaust in the vulcanizers. There are a large number of turbines so installed that steam can be bled from one of the upper stages. Such operating conditions increased the difficulties of the turbine designer but he seems to have met them with success.

Some of our industries, such as sugar refineries, some chemical works and some paper mills, have a greater demand for heat than for power and can, therefore, obtain all their power as a by-product. In such industries, one demand exactly balances the other but, in many others, the demands do not occur during the same periods. Steam accumulation, in some cases, has been used to iron out these inequalities of demand but the apparatus is expensive and often the increase in fixed charges is greater than the fuel saving. Installations such as these usually presuppose either an exact balance of power and heat requirements or separate generation of the excess power requirements. There are numerous installations where these conditions do not prevail but where so much steam for heat is required that, if it were all passed to by-product turbines, the factory could not absorb the power generated. It is usually the practice to generate the process steam at the pressure required and to either purchase the power requirement or generate it in from other boilers.

Three Main Classifications

We have, therefore, three main classifications based on fuel costs under which a factory is justified in generating its own power.

1. When power requirements are large and sufficient condensing water can be obtained.
2. When the entire power can be generated as by-product power.
3. When, through co-operation of the factory and the utility, the entire steam or heat demands of the factory are used for the generation of by product power and the difference either purchased from the local utility or sold to it.

The first two divisions have been discussed so frequently it is unnecessary to further comment on them but the third we are only beginning to study. It is a far more complex problem; one that requires not only expert engineering study but also frank and open discussion with the utility. This classification naturally subdivides into two parts:

a. Factories requiring more power than can be generated as by-product power:

b. Factories that can generate more by-product power than required for their own uses.

The solution of the problem for the first subdivision (a) is generally either that of operating two boiler plants, one for heat and the other for power, or by purchasing all power and generating steam at low pressures.

If the excess requirements are small, very little additional labor or investment is required beyond that for the process steam plant and the central station cannot compete.

If the excess power required is relatively large and the steam demands small, (b), it is often best to abandon power generation and build only a low pressure boiler plant requiring minimum investment and supervision. The elimination of a power department, thus giving the management more time for other duties, is a justifiable reason for not including generating equipment.

A "No-Man's-Land"

There is a broad "no-man's-land" between these sets of conditions and, in this field, there is opportunity for considerable engineering study. The best central station performance yet reported shows a kilowatt hour produced for less than 14,000 BTU. Rates of 16,000 to 20,000 BTU per KWHr are about the average of the better stations. The industrial plant cannot hope to meet these records except through by-product power. Such power is obtained with a heat consumption that may be expressed as follows: BTU per KWHr=(Heat equivalent of KWHr).

+(Generator losses)
+(Mechanical losses)
+(Radiation losses)

or, approximately (depending on size and type of unit),

$$\text{BTU per KWHr, at throttle}=\frac{3415}{.92\text{x}.95\text{x}95}=4100\text{ BTU.}$$

This figure if divided by 75% boiler efficiency would represent 5500 BTU per KWHr or less than a half pound of coal. In other words, given the right conditions, it is possible to generate factory power as a by-product at less than half the fuel consumption of the best type of central station. It has been done for years in sugar refineries and industries with similar conditions.

The exact balance in a sugar refinery has been obtained only by years of most careful study. It has required changing the type not only of generating equipment but of refinery equipment as well. It has required the studies of the use of exhaust steam by the refinery and of the prime mover. Often, larger savings can be made by a study of the use of the steam than by refinements in the power generator. This fact is too frequently lost sight of. This exact balance can be obtained very rarely hence we must compromise. There are almost as many combinations as there are factories even in the same industry. We can only briefly mention a few.

Plant A requires a large quantity of live steam and little power. The steam is lost in the process; hence, the feed water is cold. If high back pressure turbines were installed and all steam passed to them, more power would have been generated than could have been used by the plant. The plant load was about 6000 KW with a very high load factor. A straight condensing plant could have delivered a kilowatt hour for a total cost of 1.06c per KWHr. The solution was found by installing two turbines, one operating high back pressure condensing and the other controlled to discharge enough exhaust steam to heat the boiler feed water. Power is produced for 0.5 cents per KWHr including fixed charges.

Plant B has similar conditions but slightly lower load factor. The cost of a complete new high economy generating plant was estimated and indicated that straight condensing generation would cost 0.96c per KWHr but that by-product power could be obtained for 0.52 cents.

Plant C, with less than 600 KW load, requires large quantities of hot water. By-product power was obtained for 0.6c per KWHr when purchased power would have cost 1.57 cents per KWHr.

Plant D requires about 3500 KW. of which 500 to 600 KW is generated as by-product power and the rest purchased. Care should be taken in the study of this last condition. If the by-product is generated at a uniform rate, the purchased power carries a lower load factor and a high rate and, although the by-product power may be obtained at a low rate, the high rate of the purchased power may upset the balance.

If all the process steam were used by plant A for power generation, this excess by-product power could be generated for about 6,000 BTU per KWHr and at a less cost than it can be generated for in the modern central station. Industries owning and operating hydro-electric stations are today selling their surplus power to their local utilities and purchasing their own shortages.

From the standpoint of economy any industry is justified in generating such portion of its power requirements as can be generated as a by-product either of process steam or waste heat, as in cement mills. This does not mean that the factory will sell its surplus to the utility at the price it will pay when purchasing from the utility. The utility will probably own the connecting transmission lines and must meet the fixed charges on its investment and the line losses. The factory will be furnishing dump power and will probably expect firm power from the utility. The rate for the latter class must include the fixed charges on the equipment set aside to provide service to the customer but, if the interchange is purely dump power on both sides, closer rates will prevail. The writer hesitates to offer this suggestion because of the possibility of misunderstanding. He does not believe such arrangements can be made immediately but is convinced that, in the larger industries, they will gradually become effective. The sizes of both the industrial plant and of the local utility will have an important bearing because the utility will be interested only in purchases that are at least a measurable percentage of their output. The industry must consent to operation in accordance with the rules of the utility operators and may have to employ some high grade men. Both parties must learn to talk and understand the same language which, after all, is probably the only real stumbling block. The economies are there and they are worth striving to obtain.

In conclusion; there is no single factor or formula that will solve all the problems. Each set of conditions must be studied separately. What is one plant's meat may be the other's poison. The writer has attempted only to point out the governing factors. The solution of each problem is in your hands. It lies in further engineering studies of both the process and power plant, and also in the closer cooperation between the factory management and the public utility.

Operating with Purchased Power In Competition with Private Power

By REGINALD PELHAM BOLTON,
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THE enormous increase in the demand for electrical energy has had the effect of reducing the ratio of overhead and distributed costs to the generating expense of large public service systems. The result has been an actual reduction in the cost of electric supply, in spite of a large increase in the cost of fuel, labor and supplies. The United States Department of Labor has published statistics showing that this increase in the elements of the cost of production of electricity is fully 80 per cent over prices obtaining in 1913. In spite of this increase, the average price of electric energy throughout the country has been reduced 8.6 per cent during the same period.

The same features, however, applied to the production of electricity by small generating plants in industrial or domestic buildings, have had the opposite effect of increasing the cost. This is particularly the case in buildings devoted to business purposes where the demand for electricity is fixed and does not require an annual increase.

Disappearance of the Small Plant

It has thus come about that the changing circumstances in the cost of materials and labor since 1913 have brought about a very rapid reduction in the economic value of small power-generating plants which, in the city of New York, has been so marked that the entire disappearance of the small isolated plant is within sight. Thus, during the past ten years, no less than 460 such plants have been discontinued in the city of New York and only 12 isolated plants have been installed in new buildings.

The process has been accelerated by the adoption of the policy, advocated by the National Association of Building Managers and other organizations interested in the operation of improved real estate, whereby the tenants of business, manufacturing and residential properties are required to pay for the use of electricity. The economic reason for the installation of a great number of small interior power plants has thus disappeared and the result has been largely to the benefit of the ownership of improved real estate.

The use of public electric service in such buildings in substitution for, or in competition with, a local or isolated plant must be considered in relation to the entire service of a mechanical nature in the building and, particularly, to low-pressure steam heating and high-pressure steam-operated apparatus, involving the employment of skilled and expensive labor. A great deal of controversy has been based on the relative costs of electric energy from private generating apparatus and of purchased electricity. This cost, however, is no more than a single element in a combination of electric energy with steam and labor and it is not a controlling feature of the combination. The real comparison is between the total costs of the combined services under one method of operation and under another. To many engineers it has seemed incredible that a reduction of expense could be made by the use of live steam for heating purposes in combination with the purchase of electricity in place of the production of electricity by high-pressure steam and the use of more or less of the exhaust steam for heating purposes. It required the exhaustive and year-long test of the power plant and the heating plant of the Hall of Records in New York City, to determine the limitations and possibilities of the utilization of exhaust steam.

The Reasons

The facts thus established, and confirmed by much practical experience with other plants, demonstrated the limitations of exhaust steam as follows:

1. Of the total quantity of steam annually produced in an isolated power plant in this latitude, no more than 30 per cent is utilized in the work of heating the building where the plant is installed.
2. There is no practical possibility of combining to advantage the steam required for electric light and power in such buildings with that required for heating.
3. Of all the steam generated in an isolated plant, from 10 to 15 per cent is lost by condensation before reaching the power apparatus.

With these considerations in view, a comparison of the economic values of an isolated power plant and of a new combination for the same services, becomes less difficult.

The subject is further interestingly affected by another element, resulting from the large increase in the value of land and in the cost of building construction, whereby the cost of the space for mechanical apparatus has greatly increased. The rentable value of spaces below the street surface, which in years gone by was almost negligible, has now become an element of considerable importance. In a number of recent instances, it has been found that the space taken by engines, generators, pumps and boilers, has an income-producing value far exceeding any advantage their operation might have over purchasing steam or electricity. It has, of course, been very unfortunate for the owners of many of these plants to find the investment made in them become, in a relatively short time, of practically no value. This, however, is a result which, perhaps, could not have been foreseen, but, in the light of this experience, it is evident the cautious investor today will hesitate to invest money in machinery and in the space necessary for its housing where the services to be provided can be afforded by an outside system.

The New Methods

The methods found successful in reducing the cost of light, heat and power in buildings of various characters, in the last few years, are simple and have the advantage of not only reducing the cost but also of eliminating much of the risk and some of the annoyances. The plan is to arrange for the operation of every mechanical service, such as pumping or the operation of elevators, by electricity. The addition of the load thus created advantageously affects the price of electricity and, at the same time, eliminates the need for high-pressure steam. This leaves, then, the problem of heating in the very simplest form. The building itself can be heated and hot water supplied with a pressure of less than 10 pounds per square inch.

Perhaps the most complicated conditions of service are to be found in hotel buildings which, in general, are very carefully supervised and operated. It has, nevertheless, been possible here to make such use of the public service, in combination with low-pressure heating, that the cost of light, heat and power has been much reduced. In a 400-room hotel in New York, although hydraulic elevators are retained, the system has reduced the total cost, per year $10,000. In a 300-room hotel, a direct saving has been announced by the proprietor, of per year, has been announced by the proprietor, of $22,000 per year. In a 1000-room hotel in Chicago, the total cost of service has been reduced by the same system, per year, $25,000.

Buildings occupied by department stores also have much use for steam service and a considerable day time demand for light and power. One of the most up-to-date of such stores on Fifth Avenue has derived an advantage of $50,000 a year by the abandonment of its mechanical plant and the use of public electricity and steam.

Institutional buildings, of the character of the Y. M. C. A., are very intensively occupied and have heavy demands for heat and hot water. The change described, of one such building, effected a direct saving of over $5,000 in the past year's operation.

A plant in a business building, which I have operated for some time, is now being removed and the space released is found to have a rentable value of $12,000 a year.

An illustration of the effect of similar changes in a manufacturing building is afforded by a printing and stereotyping concern, whose plant had been in operation less than ten years and, which, by using gas to raise steam for certain processes and buying electric energy, gets equal service at a reduction of $22,000 a year. These problems now confront many members of our profession. The engineer must face all alternatives and be prepared to suggest, even if it be to his own personal disadvantage, the adoption of new methods and new economies, reduction in expense, and lessened investments.

(Record of Conference will be concluded in October issue.)

Culture Versus Engineering Education

By G. S. WYKOFF
Purdue University, Lafayette, Indiana

THE engineer today is a specialist. At the same time he is intensely practical. Everything that he does, that he reads, that he thinks, even that he dreams, must have an application which must further practically the work on which he is engaged. There is no place in his life for spiritual things, for things of beauty, of appreciation, of culture, and there is no time, even in his hours of recreation, to devote to the enjoyment of literature, art, or music. He can only exist, not live; he can only earn, not enjoy.

The cause of all this is readily apparent, for it is the attitude the engineer adopts at the very beginning of his preparation for his profession—the attitude of specialization which unfortunately, at this stage of civilization in America, is the predominant one in all professions. In some of these, like that of the lawyer, the teacher, the minister, and the artist, cultural things are acquired naturally, as a part of one's preparation. But the case of the engineer is different. From the day he has chosen his life work—usually in high school or at the very beginning of his college term—he feels that he must specialize intensely, that the need of his profession is great and the time of his preparation is short, and that everything with the least tinge or impracticability, with the faintest coloring of spirituality, is to be shunned like a hideous disease. He can be made to study subjects if he can be shown they are practical and will lead to the advancement of both himself and his profession. But if the subject is one whose content is only to be appreciated, to be enjoyed as a thing of beauty, then the engineering student closes his mind like an oyster its shell, and he remembers only enough of this necessary evil to make a passing grade in the course.

A natural consequence is that the engineer is quite ignorant of any subject that lies outside his own immediate field. I have been teaching engineering students for several years, and each succeeding class seems to make more apparent this attitude of narrow-mindedness and practicality, this neglect and ignorance of cultural things which help to make life beautiful. True, my students have been mostly freshmen and sophomores, but a rather close observation of upperclassmen, and even of young engineering graduates, has served only to confirm the impression.

For instance, not so long ago I asked two of my classes—about sixty sophomores—certain questions about literature. The answers were surprising.

They were asked to identify Carl Sandburg, Hugh Walpole, Vachel Lindsay, Harriet Monroe, John Philip Sousa and Otis Skinner, all of whom had visited the university or the city during the three preceding years. Few identified all correctly, while answers like the following were not unusual: Vachel Lindsay is a German musical composer, a statesman, a historian, an English authoress; Otis Skinner is an American poet; Carl Sandburg is an American cartoonist.

Other questions asked were these: 1. Name six living American poets. 2. Name six living American novelists. 3. Name six living English poets. 4. Name six living English novelists. 5. Name six operas. 6. Name six musical composers (living or dead). 7. What are the Pulitzer prizes?

No perfect papers were turned in, and not many that were anywhere near perfect. In many cases, most of the questions were left unanswered. Zane Grey, Rex Beach and James Oliver Curwood were listed most frequently as the novelists, and Edgar Guest and Robert W. Service as the poets. The few students who had heard of the Pulitzer prizes knew of them in connection with the airplane races. "The Old Soak" and "The Cat and the Canary" were given as titles of operas.

Not more than ten per cent of each class had attended the various musical and dramatic events—few but excellent—at the university or in the city. Six only of the sixty had seen Otis Skinner in "Sancho Panza," and only seven had attended two concerts by an excellent little symphony orchestra.

Most of these students demanded authority for the statement that cultural things are important in an engineer's life. It was not hard to find: in fact, it was in one of their own textbooks. John Butler Johnson (died 1902), a practicing engineer and later Dean of Engineering at the University of Wisconsin, in an address, "Two Kinds of Education for Engineers," said in part: "The one crying weakness of our engineering graduates is ignorance of the business, the social, and the political world, and of human interests in general. They have little knowledge in common with the graduates of our literary colleges, and hence often find little pleasure in such associations. . . . . For your own personal happiness, and that of your immediate associates, secure in some way, either in college or after leaving the same, an acquaintance with the world's best literature, with the leading facts of history, and with the biographies of many of the greatest men in pure and applied science, as well as of statesmen and leaders in many fields. . . . . This kind of knowledge, also, elevates and sweetens the intellectual life, leads to the formattion of lofty ideals, helps one to a command of good English, and in a hundred ways refines, and inspires to high and noble endeavor. This is the cultural education leading to appreciation and enjoyment man is assumed to possess."

Engineering students are fair-minded. When they speak frankly, they admit that literature, music and art are good things, that they should like to know more about them, but that most of their time is needed for their own special engineering subjects, and what little time remains they spend in other kinds of recreation.

Now, is such a condition deplorable and undesirable? Many will say no, others yes. Some of us feel that there are many good things in life—cultural, it is true—which the engineer is missing, and which he really cannot afford to miss. We realize there is not time even for a cursory study of music, painting and literature, and we turn to the last-mentioned as possessing the highest cultural value of the three, believing the general definition that "Literature is life." We think that an engineer can, should and would appreciate such gems of poetry as Shelley's "To a Skylark" or Browning's dramatic monologues; that he would enjoy some, not all, of the older novelists; and that the better modern dramas and better musical comedies would and deserve to appeal to him more than such insipidities as "Getting Gertie's Garter" or "Parlor, Bedroom and Bath."

Our universities are making only a feeble attempt to remedy matters, although the assumption is safe that even a concentrated effort would not meet with much success. In English, for example, there are few elective courses, because there is no demand for them, and the required English courses have bowed the knee to the god of practicality. A study of the curricula offered at our various technical universities shows these things plainly, as a few examples will indicate:

At Purdue University there are four required semesters of English: three of them are practical, two being English composition, the third public speaking. Of the elective courses, those in business writing and in public speaking are the most popular. Elective literature courses are almost wholly neglected by the engineering students. At Massachusetts Institute of Technology a combined course in English and history is required, the first two years; during the last two years, four terms of general study subjects are required, chosen from a varied list grouped under these headings: Social Political, Economic and Business Subjects; Literature, English, History and Fine Arts; Science and Foreign Literature. At Cornell University one year of English composition fulfills the engineering requirements. At the University of Illinois engineering students are required to take only one year of English, this work consisting of rhetoric and themes. And at the University of Michigan, of the 140 hours of credit work required before the degree of Bachelor of Science in Engineering is conferred upon a student, only six hours need be in English.

There is a tendency now current to shorten the engineering courses and make them still more practical and intensive. If such a plan is adopted, undoubtedly the subjects of study eliminated will be the so-called impractical and unnecessary courses in English and literature, and after them perhaps history and the languages.

These, then, are the conditions at present. In the future will there be a more favorable attitude on the part of the engineer towards spiritual and cultural things, or will culture, in its broad sense, and engineering education continue to be almost diametrically opposed?

NEW BOOKS

BOOK REVIEWS

The Building of the Delaware River Bridge—An Interesting Record. By Charles Carswell, Assistant Engineer. 75 pages, 10x12, very fully illustrated, paper cover. $1.00 net.

A story of the early efforts to bridge the Delaware River at Philadelphia is followed by an account of the location, construction (including many details of the structure and erection), together with a complete record of contractors with amount paid each, and a tabulation of the total cost of the structure. This publication will be of value to every bridge and structural engineer.

Steel Structures—Stresses in Simple Structures. By Leonard C. Urquhart, Professor in charge of Structural Engineering, Cornell University, and Charles E. O'Rourke, Assistant Professor of Structural Engineering, Cornell University. 278 pages, 6x9, 214 illustrations. $3.50.

The fundamentals of stress calculation in simple structures. Both graphical and analytical methods are shown in most cases. While the relation between graphical and analytical methods is emphasized, the methods have been separated so that each may be taken up separately. Both methods are illustrated by actual numerical problems.

Ports and Terminal Facilities. By Roy S. MacElwee, Commissioner of Port Development, Charleston, S. C.; formerly Director U. S. Bureau of Foreign and Domestic Commerce; formerly Dean, Georgetown University School of Foreign Service. Second edition, revised and enlarged. 446 pages, 6x9, 276 illustrations. $5.00.

A thorough and detailed discussion of marine terminal facilities. This revision is practically a new book. It discusses the problem of material equipment of ocean gateways from the point of view of low costs of maintenance and operation, through proper design for the work in hand. It covers thoroughly the design and construction of marine terminal facilities.

Airmen and Aircraft. By Major Henry H. Arnold, Air Service, U. S. Army. $3.50.

The publisher says it is "the living, throbbing epic of man's conquest of the air to date, told in everyday language by a pioneer air pilot. Fascinating as a novel yet makes you realize keenly the wonderful future possibilities of aerial navigation in its commercial and military applications."

Design of Diagrams for Engineering Formulas and the Theory of Nomography—By L. T. Hewes, Deputy Chief Engineer, United States Bureau of Public Roads, and H. L. Seward, Associate Professor of Mechanical Engineering, Sheffield Scientific School, Yale University. 112 pages, 9 x 12. 82 illustrations. $5.00.

The special features of the book are: the presentation of a new class of diagrams—diagrams of adjustment, which open up a wider field of nomographic representation; practical methods of using determinants and the projective transformation; practical applications of nomography based on broad mathematical theory.

Punches, Dies and Gages—By Albert A. Dowd and Frank W. Curtis. 341 pages, 6 x 9. 171 illustrations. $3.50.

This new book—the third and final volume in the Dowd and Curtis Tool Engineering series—contains an exhaustive discussion of dies—both for forging and for the punch press; the design of gages for interchangeable manufacture; the limit system; modern drafting-room practice; elementary pattern work; feeds and speeds; cutting lubricants, etc. This book should be in the library of every progressive tool engineer; every machinist; every toolmaker, draftsman, foreman and shop owner.

ENGINEERS & ENGINEERING

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Business and Banking

IT would have been strange if the disaster in Florida and other Gulf Coast States, last month, had not brought with it a hesitation in business. That its effect was seen more in financial than in commercial markets might be regarded as somewhat usual; but much as it may have been deplored, both business and finance came to early realization that the damage done was so scattered among many property owners as to involve no large single interests, and to probably bring new business to many industries as the work of reconstruction goes on, if it does. The toll on the insurance companies was not sufficiently heavy to bring about investment liquidation for the purpose of providing for damage claims. In fact, the injury to finance, if it may be put that way, will not be seen until the extent of borrowing on properties now wrecked is known, and it can be ascertained whether the owners can carry the cost of rebuilding on top of a present indebtedness, as well as to what extent the results of countrywide collection of relief funds will help.

Florida had passed through only a few years of extensive development. Much recent colonization had taken place in the district swept by the storm, but many who went there already knew that they had overpaid for what they bought, just the same as those who had made loans on the homes and other properties were concerned about the safety of their advances because of sharp declines in values. Another feature of the situation is that many of the homes in the locality were for winter occupancy, in the luxury class so to speak, and the inference is that rebuilding is likely to be slower than it would be in any other section of the country having the same property wealth; thus spreading such business as might be accelerated over a longer period of time and probably also spreading the losses.

* * *

In all other respects the activities of business go on as they have been during the past year or two, with nothing in sight to indicate that present good conditions will not continue until at least the end of this year. In this all students of business economics seem to be agreed. The situation is perhaps best expressed in the Guaranty Survey for October which, in part, says:

> "Goods of all kinds are readily moving through the successive stages of distribution. Employment is large, and wages, instead of lagging behind the general price level, have advanced more rapidly than the cost of living, resulting in an unusually even distribution of purchasing power and of demand for the various classes of commodities. Consequently, both industrial activity and prices are well balanced."

So long as this condition lasts, and as previously stated there appears to be no check at present in sight, what now seems to be a cloud on the horizon need not be feared. The weakest feature of present business is the volume of lending to poor borrowers—installment selling. There has not yet been a serious business reaction that was traceable directly to inflation of this kind; neither was there ever so huge a volume of sales of merchandise, of so many classes, which immediately get the depreciated values of second-hand goods for a small "down" payment. The advancing of working capital to businesses in order that they may extend more credits has become a large undertaking, and it does not balance with the rest of things. Savings deposits, in the aggregate, were never so big as now, the per-capita ownership of circulating money never so large and the use of safe deposit boxes in the banks never so general. It is not easy to imagine any early reaction in business sufficiently severe to bring about unemployment enough to force this condition to an issue, and it would be just as difficult to forecast what the outcome might be if such thing should occur; neither is it easy to reason why people buy so much as they do on deferred payment plans unless it is that a strong selling force meets with only a weak sales resistance.

But as an offset to this are two indices that may be considered reliable, the one being that the production of manufactured goods is being kept very close to consumption, and the other that the best examples of business done wholly on a cash basis (and in large measure cash in advance), the chain stores and mail order houses, show constantly growing volume of sales. So that, should there be sharp recession in instalment buying, or unusually large failure to pay for things already contracted for, the addition to merchandise on hand would probably not involve extraordinary borrowing from the banks, neither should it seriously harm those not engaged in credit business.

And in this connection comes an interesting discussion by Mr. Henry Hazlitt, of the editorial staff of the New York Sun, who, speaking before the American Statistical Association, said, in part,

"Disregarding minor fluctuations, the weight of probability for the next decade is heavily in the direction of lower commodity prices. On the one hand, the value of goods, chiefly as a result of increasing supply from what promises to be a continued advance in productive methods, should go down. On the other hand, the value of gold, in which prices are expressed, should, as a result of monetary uses, go up. But even if we could calculate these elusive physical factors exactly, it would be folly to attempt to forecast just how far the decline in prices is likely to go. Certainly there is nothing sacrosanct about the 1913 level of prices, though the fact that this is given the value of 100 on most index numbers may lead some of us unconsciously to regard that as the real 'normal,' a sort of economic sea-level. There is no sea-level in prices. There is no reason, however, why the future decline in prices should not be gradual and mild. It could easily be accompanied by activity and reasonable prosperity in general trade. Indeed, this is precisely what has happened in the last year."

* * *

An outstanding illustration of improvement in business efficiency is found in steam railroad transportation. As expressed by Col. Ayres, of the Cleveland Trust Company:

"Improvement in freight service will effect a saving to the American people this year of as much as a billion and a half dollars as compared with what the cost would have been under conditions prevailing five years ago. * * * The commerce of the country is now being transported at rates which will probably effect a saving this year of nearly $750,000,000 from what the cost would have been for the same amount of freight moving at rates prevailing in 1921. This single amount is half the total saving claimed. Most of the rest consists of indirect savings resulting from prompt and rapid shipments, and a constantly adequate supply of cars."

"The hand-to-mouth buying which has characterized American business in ever increasing degree since the great depression of 1921 has been made possible by the efficiency of railroad freight service, which has enabled merchants and manufacturers to reduce inventories and speed up turn-over. * * * The roads have not only moved more freight faster, but they have themselves earned increasing profits."

* * *

According to the Commercial and Financial Chronicle, a total of $4,945,804,772 par value of new security issues was floated in the United States during the eight months ended August 31, 1926. This is an increase of over 140 million dollars when compared with the same period during 1925. Of this total of nearly five billions, less than 600 millions was for the purpose of refinancing maturing or called obligations and less than 250 millions was for foreign account. The total is the largest up to now, and the known condition is that the security issues have been practically absorbed by those who invest. Investment dealers have no unusual stock of securities on hand; rather are they short, the shortage being particularly in the choice issues. The information conveyed is, of course, that regardless of a smaller volume of bond transactions on the stock exchanges as well as a tendency downward as to prices during September, private sales during 1926 have been greatly larger than before.

The stock market during September was irregular and reactionary. It had the appearance of a summer market, and, with the exception of the indecision immediately following news of the Florida catastrophe, it probably was a summer market period. Many vacations extended past Labor Day.

Conservative opinion in respect to the immediately prospective investment market leans toward expectation of continued activity with rising security prices for meritorious bonds and stocks; in the speculative section opinion is divided between expectation of continuation at about present levels and anticipation of larger daily transactions with rising quotations. The November elections, however, will probably have important bearing on this, and dealings toward the end of October will be influenced by the political outlook.

FREDERICK CARLES.

Items of Interest

DEPARTMENT OF COMMERCE
Washington

Gas Hazards Encountered by Everyone

Almost every individual in his daily life is subject to possible danger from asphyxiation, by fire or explosion, due to one or more of the combustible gases used for the production of light, heat and power, the prime essentials of our modern industrial civilization. Any combustible gas or vapor, when mixed with air or oxygen within certain limiting proportions, will explode on ignition. The violence of the explosion varies with respective proportions of air and gas, and with the degree of confinement of the mixture.

Carbon monoxide is produced in the burning of materials containing carbon, such as natural gas, coal, coke, wood, gasoline, explosives, etc., whenever the supply of air or oxygen is not sufficient for complete combustion. It is a major constituent of water gas, producer gas, blast-furnace gas, and coal gas. Automobile exhaust gas contains 3 to 12 per cent of carbon monoxide. Pure carbon monoxide is colorless, tasteless, and odorless. It has practically the same weight as air. Like the copperhead, it strikes its victim without warning. Very low percentages, such as 0.1 to 0.15, if inhaled for one hour or more often give a characteristic warning headache, but higher percentages usually render the victim unconscious without warning.

Carbon monoxide is the poisonous constituent of automobile exhaust gas, which contains an average of 6 to 7 per cent. It is suicidal to run an automobile engine in a closed garage for ten minutes. By actual experiments at the Bureau of Mines, dogs became unconscious after a motor was run 10 minutes in a single-car garage, with the doors and windows closed. Garages in which repair work is to be done should have good ventilating systems. It is a good plan to connect a hose or pipe from the muffler vent to the outside of the garage.

Gasoline fires and explosions are among the most common of present-day hazards. Only 1.5 per cent of gasoline vapor in air is sufficient to make an inflammable mixture. Air flowing over liquid gasoline, and many crude oils, readily becomes charged with enough hydrocarbon vapor to transmit flame on reaching some source of ignition such as a flame, an electrical spark, or short circuit. A current of this vapor-laden air has been known to transmit flame several hundred feet from the source of ignition. The ship-repair companies have found it necessary to observe most rigid precautions in removing all traces of oil from ship bunkers before making such repairs as riveting. Tests by actual analysis of air from the cleaned bunkers are made before repair work involving heat or flame is started. For making such tests, the Bureau of Mines has developed the portable Burrell gas indicator, with petroleum vapor scale.

With the growth of the by-product coking industry an increasing quantity of benzol-blend motor fuels has come into use. These fuels have definite anti-knock properties and therefore make desirable additions to our motor-fuel supply. Benzol is also used as a solvent in many industries. It is a volatile liquid, similar in this respect to gasoline. It likewise forms explosive mixtures of vapor with air, but its vapor on inhalation is poisonous. Low concentrations, if inhaled for long periods, destroy the blood cells and produce a chronic anemic condition. There is no danger to the user of benzol blends for motor fuel, excepting the usual carbon-monoxide hazard in the exhaust. Workers in the benzol plants should be safeguarded as far as possible by the installation of adequate mechanical ventilation, and these workers should also be given monthly medical examinations so that incipient benzol poisoning may be detected. Protective appliances for benzol are the same as for gasoline.

Under the subject of combustible gas hazards, the explosion and asphyxiation hazards in street manholes and sewers may be included. Such explosions occur from time to time in most cities, and are commonly caused by the accumulation of natural or manufactured gas from leaky mains, or in the case of sewers, by drainage of gasoline or volatile inflammable solvents into the sewers. In cities using manufactured gas the danger from carbon-monoxide poisoning is also to be considered by workmen who must enter these manholes. As a rule, manufactured gas can be detected by its odor and by tests for carbon monoxide, but natural gas may be present in explosive quantities without giving off much odor. Tests for gas should always be made before entering manholes and if gas is present, the manhole should be ventilated with portable blower and canvas pipe before entering it to begin work.

The oxy-hydrogen flame has been used for lead burning for many years, but in recent years the use of compressed oxygen with compressed acetylene, ethylene, and compressed liquid hydrocarbons from natural gas or cracked hydro-carbons, has become well-nigh universal in the production and fabrication of iron and steel. In fact, compressed oxygen is used in almost all industries. Gases for these cutting and welding torches are transported and used from steel containers in which they are confined under high pressures. Acetylene is confined under lower pressures in solutions of acetone and other solvents, because of its susceptibility to explode when put under pressure by itself. Other heavy hydro-carbons from natural gas, or cracked products of natural gas or petroleum, are compressed to the liquid state and confined in steel cylinders. All of these combustible liquids gasify on release of pressure and are used for high-temperature flame torches in conjunction with compressed oxygen. All containers for compressed gas should be tested by hydraulic pressure at higher pressures than that for which they are to be used. They must be absolutely clean before charging them with gas. Oxygen containers must be absolutely free from even traces of oil, organic matter, or in fact, any combustible substance. Compressed oxygen is a very dangerous substance. An oxygen cylinder containing no more than a film of oil on its inner surface is just as truly an explosive as nitroglycerin.

Ammonia and sulphur dioxide are the gases commonly used in refrigeration. Neither is poisonous in low concentrations, but they are both strongly irritating to the eyes and membranes of the throat so that one has ample warning of their presence. Most persons can detect as little as 5 to 15 parts of sulphur dioxide per million parts of air by odor and eye irritation; 0.05 per cent of sulphur dioxide is acutely pungent and produces a sense of suffocation; 0.2 per cent is intolerable.

Further details regarding the hazardous gases commonly used in the industries and the home are contained in Information Circular 6009, copies of which may be obtained from ENGINEERS AND ENGINEERING.

Automatic Signals and Train Control

Extension of automatic signals and train control devices now being made on the Pennsylvania Railroad involved expenditures totaling $8,000,000, the greatest investment and most extensive installation in signal protection ever undertaken on any railroad at one time.

Important new principles to guard against failures in the observance of signals are being worked out. A new device has been designed which consists of electrically operated mechanism by which the indication given by the "wayside" signals—that is the signals displayed on masts at the side of the track or on overhead signal bridges—is duplicated in miniature within the engine cab, keeping the indications continuously before the engineman and fireman. In addition, each "less favorable" indication is immediately called to their attention by an audible warning—a whistle. There are two sets of signals in the cab, one on the engineer's side and the other on the fireman's side. Thus, each will receive an identical separate warning.

A train control system involving these cab signals, and what is known as a "stop and forestaller" device, has just been completed on the main line tracks between Harrisburg and Baltimore. This involved the equipping of approximately 150 locomotives with the necessary electrical and mechanical apparatus for the operation of this system, which is actuated by electrical circuits in the track itself.

The present program of The Pennsylvania Railroad for the extension of cab signals and train control covers the main line from Harrisburg to Altoona, the main line from Camden to Atlantic City, the main line of the Panhandle Division from Pittsburgh to Columbus, Ohio, and the main line of the Columbus Division from Columbus to Indianapolis.

When the current program is completed approximately 1,150 engines will be equipped with the cab signals and other control devices, while the necessary electrical apparatus will be applied to 1,530 miles of track.

The "stop and forestaller" is a device so arranged that as a train passes a signal showing any indication except "clear," the air brakes will be automatically applied unless the engineer "acknowledges" the signal, as repeated in the cab, by working the "forestaller" controlled by a small lever in the cab. This action "forestalls" the automatic operation of the air brakes, but of course will not be taken unless the engineer has observed the signal and is therefore informed as to the track conditions ahead, permitting him to bring his train under control.

Engineering and transportation authorities credit the Pennsylvania Railroad with having been a leader in the perfecting and adoption of devices for increasing safety in train operation for more than half a century.

Progress Report on Public Works and Employment Stabilization

The bill which was introduced in the House of Representatives in December, 1925, authorizing the appropriation of $150,000,000 for the construction of public buildings at the rate of $25,000,000 per year for the next six years, stirred up a great deal of opposition at the start because it took away from Congress and gave to the Secretary of the Treasury powers which Congress had always jealously guarded. Sponsors of the bill were very nervous because of this opposition. Our group asked for a hearing before the House Committee on Public Buildings to present reasons for constructing more than one-sixth of the six year total in years when private building declined. Congressman Richard N. Elliott, of Indiana, chairman of the committee, opposed the hearing and the matter was not brought officially before the House Committee.

After the bill passed the House we persuaded Senator George Wharton Pepper of Pennsylvania to present the following amendment in the Senate: "The Secretary of the Treasury shall take into consideration the stabilizing effect a governmental construction policy may exert upon general employment and industrial activity and shall report to Congress with recommendations whenever the volume of construction in the United States during any period falls one-third below the volume of the corresponding period of nineteen twenty-five."

The principle of long range planning of public works was supported by Secretary Mellon and Secretary Hoover. Senator Bert M. Fernald, of Maine, chairman of the committee, agreed to accept the foregoing as a committee amendment, suggesting, however, that Senator James Couzens, of Michigan, should have the privilege of presenting the amendment on the floor because he had first brought it to Senator Fernald's attention. Senator Pepper agreed. The bill was under discussion for several weeks. It came to a vote unexpectedly on a day when Senator Couzens was not on the floor and when Senator Fernald was not able to reach him by telephone. In this way an accident undid six months of hard work.

We believe the Treasury Department will endeavor to carry out our principle by asking for larger appropriations for public works in future years of diminished private construction.

In the next session of Congress we shall need help in getting this same principle applied to federal appropriations in aid of state road building, and to federal river and harbor work, aggregating about $150,000,000 a year. The national publicity which can be obtained through national legislation will help to get it considered for state and municipal practice.

Your steady interest is needed and your comment will be welcome.

OTTO T. MALLERY,
112 S. 16th St., Philadelphia.

How a Railroad Uses Motor Cars

An interesting 4-page leaflet by Elisha Lea, Vice-President of the Pennsylvania System, has recently been published. It tells how the Pennsylvania Company is using, and planning to use, motor busses and trucks in handling short haul passengers and freight.

Copies are available on application to ENGINEERS AND ENGINEERING.

A Preliminary Experiment on the Supporting Strength of Culvert Pipes in an Actual Embankment

The experiment described in this bulletin was planned to determine for different kinds of culvert pipe, embankment materials and field conditions, the ratios between the supporting strengths which culvert pipe can safely be counted upon to develop in actual use and the laboratory strengths of such pipe when tested by standard methods.

The measurements of side pressure by earth pressure cells varied widely, but in a general way the result confirmed the conclusion that the active horizontal pressure in a mass of granular materials can be computed with fair accuracy by Rankine's formula for horizontal earth pressures.

The bulletin contains interesting data, tables and illustrations. Copies can be obtained from ENGINEERS AND ENGINEERING, price 30c net.

The Cause and Prevention of Embrittlement of Boiler Plate

By SAMUEL W. PARR and FRED G. STRAUB

At the outset of the investigation it was determined that it would be desirable to make a critical survey of the situation with a view to establishing beyond any question the facts, pro or con, as to the actual existence of such a thing as embrittlement. There has come somewhat persistently into the discussion of the topic both references to embrittlement as an actual fact and discussions making use of the expression "the embrittlement myth," implying a question as to the reality of embrittlement. Hence, the initial phase of these studies was directed towards proof of either the existence or the absence of the phenomenon.

The general conclusions given in this bulletin, as a result of the investigation, may be summarized as follows:

(a) Embrittlement in boiler plate is caused by the combined action of stress and chemical attack. The stresses are inherent in the construction and in the operation of the boiler, while the chemical attack is caused by sodium hydroxide in the boiler water.

(b) Certain methods of water treatment tend to convert some safe waters into the characteristic type of water which produces embrittlement.

(c) The presence of sodium sulphate in the feed water and undecomposed sodium carbonate in the boiler water tends to retard the embrittling effect of carbonate waters, and if these are present in proper proportions they will stop it entirely.

(d) Methods for introducing sulphates in boiler waters have been worked out to the point of practical application.

Copies can be obtained from ENGINEERS AND ENGINEERING, price 35c net.

A Conference on Bituminous Coal will be held at the Carnegie Institute of Technology in Pittsburgh, November 15 to 19, 1926.

The purpose of the meeting is to bring together men of all countries who have done notable work in the study of more scientific and rational utilization of soft coal. Listed for discussion are such questions as the manufacture of substitutes for gasoline from coal; the complete gasification of coal; high temperature and low temperature carbonization; by-products; smokeless fuel; pulverized coal; hydro-electric power versus steam power, etc. In other words the purpose is to discover how soft coal can be made more valuable.

Among those who have accepted invitations to be present and to speak are: Dr. Friedrich Bergius, of Heidelberg, Germany, inventor of the Bergins method for the production of oil from coal; Professor Franz Fischer, Director of the Institute of Coal Research, Mulheim-Ruhr, Germany; Dr. C. H. Lander, Director of Fuel Research of the Department of Scientific and Industrial Research, London; Dr. R. Lessig, Consultant in Fuel Technology, London; Geoffrey M. Gill, Consulting Engineer and Gas Specialist, London; Harald Nielsen, inventor of the L. and N. Process, London; General Georges Patart, of France, inventor of a process for making methyl alcohol from coal; Marius R. Campbell, U. S. Geological Survey; A. C. Fieldner, U. S. Bureau of Mines; John M. Weiss, Chemical Engineer, New York; S. W. Parr, Professor of Applied Chemistry, University of Illinois; C. V. McIntire, of the Consolidated Coal Products Company, Fairmont, West Virginia; Walter E. Trent, New York City; Dr. H. W. Fulweiler, Philadelphia; Dr. Horace C. Porter, Philadelphia.

Papers will be presented by a number of other American and European technologists. Special attention will be devoted to the discussion of recently developed processes which are in actual operation.

Invitations to the Conference will be sent to individuals who are interested and to scientific and industrial organizations.

The Flettner Rotorship*

By F. O. WILLHOFFT
Consulting Engineer, New York

RARELY has an invention evoked such general interest among laymen as well as engineers as the Flettner Rotorship. This is not to be wondered at when we consider the extreme novelty of the invention, the unusual appearance of the rotor, and the apparent mystery of its action. But particularly owing to the fact that once more windpower is utilized to propel ships, after the sailship, with or without auxiliary engine, has been practically discarded by the shipping world. According to the latest statistics by Lloyd's, only about 3 per cent of the world's tonnage are sailing ships. It would seem to be unnecessary to refer to the underlying theory of the rotorship but, in spite of the widespread publicity it has received, there are still many misunderstandings concerning the theory as well as the purpose and scope of the rotorship.

The Rotorship "Baden Baden," now in this country, was originally a 150 foot three-masted schooner. The rotors were installed merely to prove that rotors are practical and safe, and to confirm the laboratory experiments. No real conclusions as to the economy of rotorships in general could be derived from the performance of this small vessel, but it proved to the shipping world that *technically* the rotor idea is sound, and Anton Flettner's predictions, based on exact laboratory experiments, were confirmed in every particular. The results were so favorable that a 3000 ton ship, the "Barbara" was ordered which will give us conclusive results from actual operation of a ship of commercial size. The data will be especially conclusive since the same firm who has chartered the "Barbara" is operating sisterships, i. e. motorships built exactly like the "Barbara," but without rotors.

The reason why even many engineers did not understand the action of the rotor is that comparatively few of them have concerned themselves with the study of aerodynamics, and because the so-called Magnus effect was practically known only to physicists. When it is stated that the action of the wind on a rotor, i. e. a revolving cylinder closed at top and bottom, is no more mysterious than the action of the wind on airplane wings or on sails, conveys no meaning to most people, even to many engineers. This is simply because they have construed their own theory about airplanes and sails, which satisfies them but, which happens to be entirely wrong.

The idea prevails that the inclined airplane wing is pushed through the air at great velocity, and that the air underneath the wing is thereby compressed, furnishing the required lift. Or, in the case of a sail, that the wind blows into it as into an open bag. The fact, however, established by actual measurement in the windtunnel, is that 60 to 80 per cent of the total "lift" of an airplane is due to the suction on top of the wing and only a small part to the pressure underneath. This shows how erroneous the popular conception is. Almost the same conditions exist in the case of the canvas sail. The primary function of the positive pressure area is not to furnish the lifting force, but to deflect the wind to the other side of the plane or sail. Since most of the air is deflected to the upper side of the wing, it has to be accelerated there so as to give a continuous flow, the same as water in the throat of a venturi tube, but the energy required to accelerate the air can only come from the store of pressure energy in each pound of air. Hence the drop of pressure, the vacuum, on top of the wing, or behind the sail.

In the case of the rotor we find exactly the same conditions. The cylinder is rotated at a surface velocity greater than the wind and the surface drags along with it the so-called boundary layer of air which, on one side, meets the wind coming in the opposite direction, while on the other side of the cylinder it travels in the same direction as the wind, but at 2 or 3 times the velocity of the wind. The result is the same as in the case of the airplane wing: The wind takes the easiest path; i. e. retardation of the air and slight pressure result on one side, and acceleration and relatively great suction on the other, the two together exerting a pressure, at almost right angle to the direction of the wind, against the total projected area of the rotor cylinder. The film taken with a rotor immersed in a current of water shows this deflection of the streamlines in a striking manner. A block of wood approaches the cylinder, reaches a point on the pressure side almost in line with the center of the cylinder, actually reverses and speeds around on the other, the vacuum side of the cylinder. The reason why one square foot of rotor area will give the same effective pressure as about ten square feet of sail area, is simply that the air is deflected more efficiently by the rotor, due to the high surface speed of the rotor.

Engineers have asked how it is possible that the actual energy delivered by one of the rotors of the "Baden Baden" is more than the kinetic energy represented in a current of air having the same crossection as the projected area of the rotor. The explanation is simply that a much wider "band" of air than that represented by the projected area of the rotor is affected, a phenomenon which we notice in all cases where the flow of air or water is disturbed by an object placed in the current.

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*Address before The Engineers Club, August 5, 1926.

The flanges at top and bottom of the rotor are most essential in order to prevent the leakage from the pressure area and the leakage of the surrounding air into the suction area. They actually add about 100 per cent to the useful pressure.

The rotors of course have to be kept rotating continuously so as to deflect the air, but the power required to do so is less than 10 percent of the energy taken from the wind and transmitted to the ship.

Among the practical questions which will suggest themselves to every engineer, after the fact is established that a rotor has the same action as a sail, only very much intensified, the most important are the following:

1. How is the stability of the vessel affected by the rotors? Do they not render it "topheavy"? What will happen to the rotors in a hurricane?

The answers to these questions bring out some of the striking points of superiority of the rotor over the canvas sail. The rotor replaces ten times the equivalent canvas sail area. To the latter have to be added the necessary masts, spars, stays, a multitude of ropes, etc., while the rotor consists of a thin metal shell, of aluminum alloy (in the case of the latest rotorship "Barbara"), effectively braced on the inside, so that its weight is surprisingly low when compared with its size, but its strength and rigidity are very great, the same as are the wings of a metal airplane. Each of the rotors of the "Barbara" weighs but 1.4 tons, while the masts and tackle alone for a sailing ship of the same size have an enormous weight. The center of gravity also is lower than in a sailing ship. As a result of these conditions the stability curve of a rotorship is much more favorable than that of a sailing ship with 10 times the sail area.

Startling, however, is the fact that the total pressure against a rotor revolving at a certain fixed speed, while at first rising in a steep curve, ceases to increase as a wind velocity of about 25 M. P. H. is reached. Two factors account for this surprising phenomenon, the first being that the ratio of surface velocity to wind velocity has a certain optimum value. As this ratio reaches a value of about 2:1, the pressure or "lift" curve bends over, reaching a maximum at 3:1 or 4:1 and then dropping off again. If, therefore, the wind suddenly increases to a gale or a hurricane, the rotor is working at a very unfavorable ratio. In addition we have the physical fact that comparatively thick cylinders have a much smaller wind resistance co-efficient than slender rods or wires, and that at very high wind velocity the so-called Reynold's effect comes into play which also prevents a rise in pressure. Due to the physical laws just mentioned the pressure against the rotors when standing still, i. e. not revolving, also increases in a comparatively flat curve, while the curve for the pressure against masts and tackle of a sailing ship, the sails being furled, is so steep that it very soon crosses the pressure curve of a revolving rotor. Since the pressure against the rotors, when stationary, never reaches dangerous values, the officer on the bridge, by a single turn of the controller handle, may reduce the speed, if the wind gets too strong, but still continue to take power from the wind, even in a hurricane. Compare this with a sailing ship in which the sails have to be reefed or furled when a storm is only threatening!

2. Granting that the rotor is a practical device for utilizing windpower, how wide is the field of application?

The answer is that there is really no type of ship which will not be benefitted by the addition of rotors. It is, of course, understood that pure rotorships, having no other means of propulsion, will not be built. One of the arguments most frequently heard by the speaker is that nowadays ship operators cannot depend on an intermittent and irregular source of power, such as windpower, and that even freighters nowadays have fixed schedules; hence people reason that the rotorship is not "practical," even though it is possible to use the rotor in every kind of weather. This conception of the limited utility of the rotors is entirely erroneous. Precisely the contrary is true: Instead of the rotorship being dependent upon the wind, the rotors render a steamship or motorship *independent* of the wind. At present a ship has engines which will give it a certain rated speed when running in smooth water over a measured course. Year in year out, however, the ship will average 10 or 15 or more percent less speed, even if engines and boilers are kept in first class condition. Why? Solely due to the action of the wind, not expressed in wind resistance against hull, superstructures, etc., which is practically negligible, but on account of the waves caused by the wind. This delaying action heretofore has been accepted as an act of God, and, since auxiliary sails have had to be abandoned, there has been no remedy, until the rotor, the modern sail, was invented. The rotor turns a liability into an asset.

How much rotor surface it will pay to give to any particular vessel will depend on the kind of service it is engaged in, its sailing route, and other individual service requirements, and naturally on the cost of the rotor installation.

While no general figures can be given at this time for the cost of rotors per square foot of projected area, it can positively be stated that the cost is not excessive and will be still further reduced by experience with actual installations.

The rotorship "Barbara" (shown on the front cover) has a single propeller coupled by hydraulic transmission to two Diesel engines of 530 H.P. each, so that either one or both engines may be used. The two together give the ship a speed of 9½ knots without rotors. It is equipped with the Flettner rudder.

The three rotors are each 13 ft. 2 in. diameter and 56 ft. high. The shells are made of Lautal metal, a new aluminum alloy. Central pivots carry the ball bearings which are 31½ in. inside diameter. It will be realized that when either one or two engines are used in conjunction with the rotors, an infinite number of variations are possible.

The results of the trial trips fulfilled exactly Mr. Anton Flettner's predictions. At windstrength No. 4 (Beaufort scale), equal to fourteen knots, the ship made a speed of 9½ knots when driven by the engine alone. With one engine only, in combination with the three rotors, the same speed was developed, or in other words the addition of the rotors resulted in a fuel saving of 50 percent, neglecting the small amount of power required to revolve the rotors. Or in this light breeze the wind contributed an amount of power equivalent to about 500 engine H.P. With windstrength No. 6-7 it was possible to maintain the same speed of 9½ knots without the use of the propeller, i. e. 1000 engine horsepower were replaced by windpower. The maximum speed obtained with rotor power only, i. e. without the use of the propeller, was 9½ knots. With windstrength No. 7 the ship will travel at about 10 knots, with windstrength No. 7-8 about 10 to 11 knots.

The rotors ran without noise or vibration. When developing 1000 H.P. the rotors were revolving at 80 R.P.M. The Flettner Rudder with which the "Barbara" is equipped, also functioned perfectly.

As a result of the trial trips, the "Barbara" was officialy taken over, and the ship was put immediately into service by the Sloman Line, Hamburg, who have chartered her and are first sending her with a general cargo to Spain and Italy, after which they will put her into the regular Hamburg-South American service. Figures based on actual operation will soon be available.

The Employer; His Responsibilities*

By CHARLES PIEZ
Chairman, Link Belt Company
President, Illinois Manufacturers Association

IN the abstract the employer is the agent who sells the labor of his workers. * * * Though the employer owns the shop and equipment, though he controls the management and the policy, though he exercises the right of hiring and firing, in the final analysis, his responsibility consists of finding a market in which he can dispose of the labor of his workers.

That being the case the price he fixes for a unit of labor cannot be satisfactory to the worker alone; it must be satisfactory to the purchaser as well. There is, in this respect, therefore, a distinct limitation to the employer's powers, and there must be a corresponding reduction in his responsibility.

I am dwelling on this relationship merely to emphasize a truth which, in the growing complexity of modern industry, is usually lost sight of, and that is that the employer in a free and competitive market, neither fixes the rates of wages, nor does he, except in an intermediate capacity, actually pay them. They are fixed and paid for by the purchasers of the commodities of which the worker's labor is a component part.

Even when the workers are organized and fix the rates of wages through the economic strength of their organizations, the purchasers still have the final decision as to whether the rates shall be paid or not, for if the rates raise the price of commodities unduly, demand lessens and an adjustment, acceptable to the purchaser, becomes necessary. Strikes that grow out of demands for increases in wages usually develop because the employer foresees the economic effect of the increase and resists it in order to save his market.

The employer's attitude toward wages, therefore, is a compromise between the expectations of the workers and the willingness of the purchaser to pay.

Failure to agree on such a compromise often results in a situation like that in the bituminous coal fields, where a considerable part of a huge industry is languishing, not because the mine operators are at fault, but because, in the open market now existing, purchasers decline to pay the advances in cost due to the union scale and rules.

* * * * *

There must be a common basis of admitted facts and principles if the industrial millenium is to be brought appreciably nearer.

No common ground can be found, for instance, between the employer who believes in the American constitution, the rights of private property, and the sanctity of contracts, and the agitator who advocates, as the only remedy for fancied or real industrial ills, the overthrow of the present social and economic system, and the establishment of the dictatorship of the proletariat.

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There must be appreciation of the fact that wages cannot be considered separately from production, that more cannot be taken out of the common pot than has been put into it.

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*Extracts from an address delivered before the Congress of American Industry, September 22, 1926.

Basing wages on cost of living and divorcing them wholly from production, was one of the calamities of the war, for it created, in the minds of many, the delusion that industry, irrespective of output, performance, or character of service rendered by the workers, can meet their expectations as to wages.

* * * * *

Congress, in its last session, abolished the Railway Labor Board, on which the public had a one-third representation, and created instead the machinery for mediation and arbitration, between railway managements and the workers, in case differences should arise. The determination of wages, upon which the entire rate structure is built, and which is, therefore, of serious moment to every member of the public, is left, in the first instance, to the railroads and their workers.

But the railroad workers are thoroughly organized, and if they wish to take advantage of their economic strength, can dictate terms to their employers. The railroads have no power to raise freight rates to recoup themselves for any advances in wages, but must depend on the Interstate Commerce Commission for additional compensation.

Yet shorn of power by an organized body of workers on one side and a government commission on the other, the railroads have been selected as the representatives of the public in any wage controversies that may arise, and they must contest unreasonable demands to the last ditch, for, unless they can count on the support of the Interstate Commerce Commission for a rate advance to cover the cost of a possible wage increase, the increase is bound to come out of their own, none too generous, earnings.

With the farmers clamoring for a decrease in freight rates, and the men for an increase in pay, the railroads are facing a difficult situation that only reasonableness on the part of the workers and their leaders can alleviate.

Through this act the public has unloaded on the railroads a responsibility which its representatives on the Railway Labor Board found it impossible to carry.

This legislation will prove an interesting experiment in determining whether a large and powerful organization can practice sufficient self control to keep its demands within such reasonable dimensions that no other group, essential to the general prosperity, will suffer thereby.

At the same time, this situation illustrates, most forcibly, the fact that the employer is the representative of the public in wage determinations, and that it is, upon his sense of fairness, his ability to determine what the market will bear, and his courage in opposing unreasonable demands, that the stability of business often depends.

* * * * *

During the exaltation begot of the war we talked glowingly of the democratization of industry, of workers' representation on Boards-of-Directors, as a cure-all for our industrial ills, but that talk was largely chimerical, and the plan, like much else that was visionary during those days of moral elation, has so far as I know been abandoned. It is well that it has been, for business is a conflict, and can't be run by a debating society.

It needs power and authority vested in a single individual to run it profitably. Leadership must exist if success is to be achieved, and no board or committee can serve as a substitute for centralized executive direction under a competent individual.

* * * * *

The distribution of the profits of industry is the perplexing problem before employers today, and the one around which most controversies center. How much does labor contribute and how much management? What is the proper return to capital to cover the interest on the investment as well as the financial risk?

If we could develop a generally successful formula to determine an equitable distribution, we would enter a long era of industrial peace and tranquility. But it is impossible! So we must continue our system of barter to determine wage rates without reference to the profits of industry. And that may, after all, be best, for labor can take no chances on profits. It must be paid promptly and fully for the work it has done. Its opportunity for increases in wages will grow out of the speeding up and intensification of industrial processes, through improvement in mechanical handling and increases in the application of power.

* * * * *

Mr. William Green, President of the American Federation, has in public utterance committed himself to a religious observance of contract obligations.

Employers are taking a greater interest in labor's condition, and appreciate that low costs are not inconsistent with high wages.

The millenium is not yet in sight, but days of better understanding are near. When they arrive, there will be a comfortable lessening of the responsibilities of the employer.

Power Production in Industrial Plants

Discussed at a Meeting Held May 18, 1926

Engineers Club of Philadelphia

Continued from page 239 September issue

DISCUSSION

H. D. SAVAGE, New York City.—The use of pulverized fuel has many applications in industrial plants and great possibilities for both fuel and labor reductions when such applications are made, but this is only one of the many opportunities offered the industrial engineer today, especially in the development of boiler room economies. These opportunities are, of course, open as well to the central station engineer, and while, in general, his plant is way ahead of the industrial boiler plant in economies, I cannot agree with Mr. Daniels* that even they are doing all they can. Some of the few outstanding ones are perhaps getting the very best results that are possible to get under any condition and they are getting them month by month, but operators of this type are still very much in the minority, though I think their influence is having a splendid effect on those less rugged engineers, and inspiring them to better efforts along the lines of improvements and economies. At present we are seing a very wonderful advance being made in the more efficient use of coal.

I saw a little thing on the front of a current magazine today, which I read as I came along on the train —"History is but a small element in the work of the engineer; tradition is almost a negligible factor and we can afford to eliminate investigation; even the toils of yesterday have but little place in the problems of today. The mechanical man's problem is how to meet the inevitable demands placed against his abilities tomorrow." It seems to me that we, as engineers, have a more wonderful opportunity today to do something for ourselves, our companies, and our country, than ever before.

Mr. Orrok spoke about the hesitancy of the industrial operator to hire a good engineer. I think that that is perhaps history. I think industrial men are realizing more and more the benefits that come from intelligently coordinated effort that may be produced by a technically trained engineer—one whose training makes him fitted to take advantage of the new mechanical devices always at hand. It has seemed to me that engineers apparently have an unfortunate habit of getting into a rut and when they get comfortably settled there, they certainly hate to be disturbed. I read the other day with much interest an article on disturbing the engineering mind and it occurred to me that my company could do all engineers a real service by having that pamphlet reprinted. I have spent the last several years promoting the use of pulverized fuel and in this work which was of a new and radical nature, it has seemed to me that the majority of engineers certainly do hate to be disturbed. What they did last week, or last month, or sometimes several years ago seems to have reached a point in their perspective that makes it appear the only thing to do henceforth and forever, and this cannot be true in the case of the combustion engineer, for I know of no field where such rapid and substantial progress is being made as in that of combustion engineering.

It seems to be a matter of history that central stations can do but little more. I don't believe it. Nor do I believe the tradition that industrial power plants cannot approximate the efficiency or economy of central stations. I do not believe there is any more reason for inefficiency in an industrial plant than there is in the central station unless it be that somebody around that particular plant does not want to be disturbed. Unfortunately, the habit has grown in the industrial plant of looking upon steam as a necessary evil and treating it more or less as such, whereas it is in many cases a very important part of the day's work. A striking example of this is the steel industry. Many of you are familiar with steel plants. The man in charge of the open hearth is an important man and gets a good salary and gets a good bonus. The head roller is one of the best paid men in the plant; he not only gets a good salary, but he gets a good bonus and so on down the line until you come to the boiler room. Now the whole plant operation really depends on the continuity of the power plant and yet, generally, they let some bright young man, that they picked up somewhere around the plant, run it. They do not pay him a good salary and he does not get a bonus. They do not provide him with the best equipment with which to do his work. They just let him peg along the best he can, and if he is a very good man, after trying earnestly awhile, he goes somewhere else and gets a job. All of this is on the basis that, well, the cost of power is but a small item per ton of steel or per yard of cloth or whatever the case may be, and yet, if you take the aggregate amount of money spent in a year in such a plant, it runs into a very respectable figure. As a striking illustration of what this indifference to the power plant means, I may cite a personal incident that occurred during the very pressing wartime operation. I happened to be in a steel mill and coming through the plate mill, noticed that they were all standing around and the rolls were quiet. I was told that they were waiting for steam. The plate mill was on a long steam line some 300 ft. from the boiler room and the engines ran on water most of the time. As we walked on over to the boiler room, I noticed that they had a steam ash ejector working full tilt. This was taking perhaps the capacity of one boiler to operate it, and yet the plate mill, one of the most productive departments in the plant, was shut down. That is only one of a number of things due to lack of intelligent engineering coordination that you can observe in any industrial plant.

There are many opportunities presented for economies in industrial plants in a by-product way. For instance, air heaters are being developed to a state of perfection that present great possibilities not only for boiler room economies, but for many uses in connection with the plant where heat for process purposes may be produced as a by-product of the power plant. In a food product plant, I have in mind, an air heater takes heat from the exit boiler gases and furnishes hot air for drying the raw product. In another industrial plant, air heated in the same manner is heating the whole plant. This must make a very considerable saving, as the plant was formerly heated with live steam.

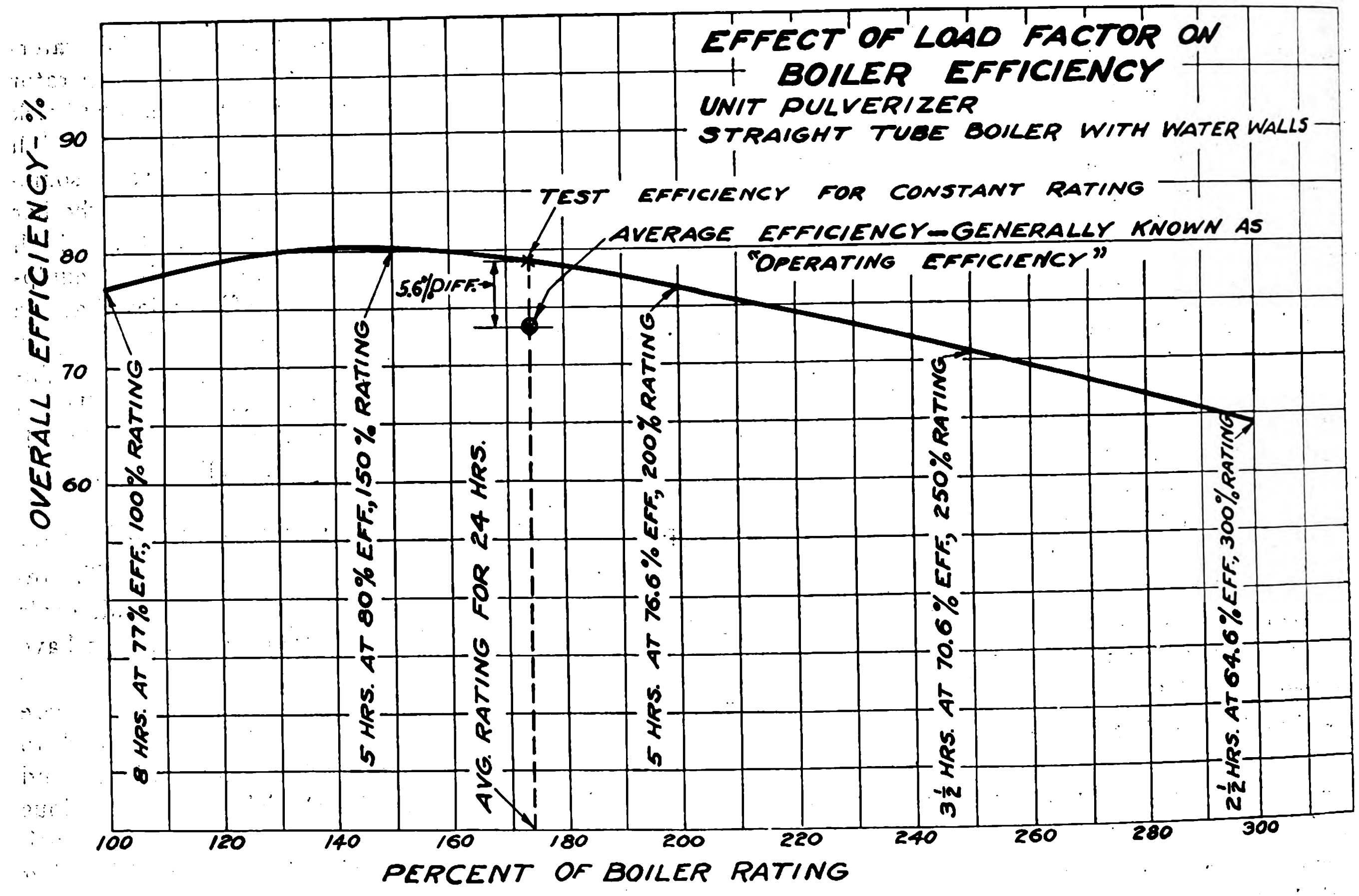
Another modern development applicable both to new and old plants is the water-cooled furnaces. There is a wonderful opportunity for capital as well as operating economies. At the Ford plant, for instance, they have recently equipped one of their 2,640 H. P. boilers, that produced under old conditions 237,000 lbs. of steam, with water-cooled walls, and this single boiler is now producing an hourly average of 435,000 lbs. day in and day out. The application of water-cooled walls to these boilers—I think there are twelve of them—will save the Ford Company a complete new boiler plant which was necessary at this time. The installation of these walls cost but little more than to have completely rehabilitated the furnaces. This rehabilitation, as carried out, not only saves a new boiler plant, but makes a very large operating saving yearly, from the fact that it cuts out the furnace repair bill. I think we all realize that if we use standard furnaces and attempt to get the full benefits of modern operation, combining high capacity with higher efficiency, that we must necessarily develop a rapid destruction of the furnaces. I believe at Hell Gate they spent something like $8,000 per boiler per year for furnace brickwork, which has been practically eliminated with the installation of the water-cooled walls. Sometimes a central station operator says, "Oh, we don't need any water walls, our brick walls are giving entire satisfaction, running at a high capacity and a high efficiency." Now there is something wrong here because with brick walls, whether air cooled or not, you cannot operate at the high capacities made possible by the improved firing equipment available and, maintain the efficiencies that are possible without very rapid destruction of brick work. There is really no justification for such maintenance expense any more, for water-cooled walls can be installed economically in either old or new installations and maintenance practically eliminated.

As Mr. Daniels has said,* we are rapidly exhausting the supplies of good coal. The available coal reserves today are getting poorer and poorer. The reserves of lignite, brown coals and the low grade coals are far in excess of the good coals to which we have been accustomed in the past. Mining methods are perhaps not quite so careful as they formerly were and we have to take the coal that is available and, to get results, we must study and employ the latest and most efficient methods. Mr. Daniels spoke of various stokers being best adapted to certain grades of coal. This is very true. No stoker is capable of burning efficiently a very wide range of fuels unless it is a traveling grate type. But if the coal is pulverized, any coal offered can be used as efficiently as the best fuel that might be secured, for the reason that the elements which interfere with the burning of low grade coal on stokers, namely, low fusing point, ash, sulphur, dirt, do not interfere with burning it when pulverized. A great point used to be made about the cost of preparing the coal. I am happy to say that engineers are broadening a little on this, and we do not hear so much about it. It never seemed to me that it was due the importance that seemed to be attached to it, for it makes no difference whether you spend your money for grimy hands to shovel the coal into the furnace, for belts to convey it, for crushers to crush it, for stokers or pulverizers to pulverize it. What you want is the most pounds of steam for the least money and the overall cost is the only figure that really matters. I believe that the overall cost of steam produced with pulverized fuel firing will always show an advantage over any other method.

J. S. BENNETT, Philadelphia, Pa.:

Both Mr. Daniels and Mr. Savage have discussed the possibilities for improving the efficiency of boiler operation in industrial plants.

I have just returned from a meeting of an Association of Manufacturers in the West. Once a year, representatives from each company get together around a big table and "swap" their experiences. During the year reports of results from every plant are



turned into a central bureau for comparison with results reported by other members of the Association. The resulting improvement in the operation of these plants is most striking. The interesting part is that a number of the plants reported an efficiency with old installations of stokers equal these given by Mr. Daniels. One plant in particular with two underfeed stokers of a design popular five years ago, had installed one modern stoker and setting. The plant efficiency rose 5% when the new unit was put into service. It would appear, therefore, that Mr. Daniels has not shown stoker and boiler performance of present day modern installations.

Mr. Daniels stated that the difference between tests and operating results is 2% for pulverized coal plants and 4% for stokers. He attributes the greater difference to an increased loss of carbon in the refuse in stoker operation. I find that there is no difference and should be no difference in so far as operating efficiencies and test efficiencies are concerned.

The incandescent fuel bed in an underfeed stoker furnace acts as a reservoir of heat, available at a moment's notice when additional air is supplied. A pulverized coal fired unit, however, must depend upon an instantaneous adjustment of the coal and air ratio if it is to operate as efficiently as a stoker fired unit. The advantage under operating conditions, therefore, would appear to favor the stoker.

The relation between test and operating efficiencies is not as simple a matter to determine as would appear at first glance. Figure I shows test results on a typical horizontal tube boiler with water walls and fired by a unit pulverizer. The length of time during which the boiler operates at each of several ratings over a period of 24 hours has been marked on the chart. It will be noted from calculations given below that the average boiler rating is 174% with an average efficiency of 73.7%. Referring to the test curve at 174% rating, the efficiency is 79.3%. This makes a difference of 5.6% between test and the so-called "operating efficiency."

Calculations

Percent Boiler Rating	Number Hours	Total Coal per 24 Hrs.*	Total Water per 24 hrs. (from and at 212° F.)
100	8	14,930	165,600
150	5	13,380	155,300
200	5	18,750	207,000
250	3.5	17,790	181,000
300	2.5	16,650	155,300
Total for 24 hours.....		81,500	864,200

*14,000 B. T. U. Coal.

Average hourly (operating) efficiency= $\frac{864{,}200\times970.4\times100}{81{,}500\times14{,}000}=73.7\%$

Average hourly rating= $\frac{864200\times100}{34.5\times600\times24}=174\%$

Test efficiency from curve at 174% rating= 79.3%.

Difference between operating and test efficiency =79.3—73.7=5.6%.

In view of the fact that the load factor alone can reduce the efficiency during operation at least 5.6% below the result obtained with a constant load, even though the efficiency during operation duplicates test results, any specific statement as to the difference between test and operating efficiency must be based on a superficial study of the facts bearing on the case.

High efficiencies reported with pulverized coal installations are due, in many cases, to the fact that the boilers operate with a slight variation in load, while the fluctuations in the load are carried by stokers.

This one phase of the question, illustrates the importance of analysing any statements regarding the relative test and operating efficiency for any type of equipment.

Modern stokers were very completely covered at the A. S. M. E. meeting in Providence, on May 5, where results from twenty-eight different refuse analyses were presented. The boiler ratings ran from 125 to 427%. Of these reports, six showed the combustible in the refuse less than 4%; ten less than 5%. while twenty-two of the twenty-eight analyses gave 6% or less. 6% combustible in the refuse with Eastern coals means only ½ of 1% of the total heating value of the coal loss. In view of these facts, it is a little hard to conceive of a loss of 4% over and above the loss under test conditions, especially as Mr. Daniels does not present results of refuse analysis from pulverized coal fired boilers compared with those operated by stokers.

I had the opportunity recently to investigate a unit pulverizer installation made by one of the well-known manufacturers of pulverized coal equipment. The excellent results reported by the operators of this plant had been largely instrumental in inducing one of the neighboring plants to consider the use of pulverized coal equipment.

The operator of the pulverized coal plant gave the following information:

1. The furnace was re-built twice to give sufficient furnace volume, while the design of the pulverizing mill was changed once. The guaranteed efficiency was obtained under test conditions after these changes, but not before.

2. A ten-hour test was conducted on a Stirling boiler operating at 227% of boiler rating with a resulting efficiency of 71½%.

3. The CO_2 of the boiler outlet was 13.05 with .08% CO.

4. The combustible in the pulverized coal refuse in the furnace was 42% with 45% carbon in the dust in the first pass of the boiler.

5. After the boiler had been operating at 170% of rating for over a week, a representative sample of the refuse from a week's run was obtained by quartering twenty samples. An analysis showed 34% combustible.

6. Pittsburgh coal was used with the heating value of 12,800 B. T. U.'s per pound, with 12% ash.

7. Failure to overhaul the pulverizer once a week produced a rapid increase in the combustible in the refuse.

8. Maintenance on the pulverizer was 10c per ton of coal fired.

Mr. Daniels stated that the saving shown in his analysis of a pulverized coal and a stoker fired plant would be increased greatly, when a poorer grade of coal was burned. Apparently the fact is overlooked that a lower grade of coal would mean more expensive furnace construction for the pulverized coal installation, pulverizers with greater capacity, greater power costs per million B. T. U.'s, and increased furnace and pulverizer maintenance. The corresponding increase in the cost of a stoker installation would be very slight.

Large furnace volumes are required for burning pulverized coal with the unit system. In analyzing six recent unit pulverizer installations, I found that the furnace volumes ran from 5 to 7¾ cu. ft. per rated boiler horse power. Central systems run even higher. The Peoria plant as example, has 12 cu. ft. of furnace volume per rated boiler horse power, with 10 of the 12 cu. ft. above the water screen. Underfeed stoker installations never run to such volumes per rated horse power. Hell Gate, with a world's record for underfeed stoker performances and boiler capacity, has only 4¼ cu. ft. of furnace volume per rated boiler horse power.

Mr. Savage mentioned the excellent results obtained with water cooled walls in pulverized coal installations. There is a tendency, however, to reduce the quantity of water wall cooling in recent pulverized coal plants, even where preheated air is used, due to the quenching effect of the cold walls on the combustion of coal in suspension.

The pulverized coal fired boilers at the Narragansett Electric Company at Providence have the side wall water tubes set far apart and placed in recesses in the walls, even though air preheaters are used.

With underfeed stokers, full advantage can be taken of the rapid absorption of heat by water walls, as combustion is not affected by wall cooling, due to the fact that most of the chemical reactions incident to combustion are completed close to the incandescent fuel bed, instead of taking place while the fuel is in suspension in the furnace.

A test was conducted on a 500 H. P. boiler equipped with a Taylor stoker at the Birmingham Water Works, with water cooling equivalent to a 1500 H. P. boiler with all four walls completely water cooled. The CO_2 in the furnace was 15.6% with

.08% CO, showing that the combustion conditions were excellent, even though cold air was used. The efficiency was over 80% at 180% of boiler rating using a dump type stoker. A low grade coal with 12% ash was burned on this test.

It is a fact that arches are being installed in existing industrial plants to give the large furnace volumes necessary when burning coal in pulverized form. The heavy maintenance charges on these refractory arches have been one of the main reasons for the rapid decrease in the use of the chain grate stoker.

Both Mr. Daniels and Mr. Savage have stated that lower grades of coal can be burned more efficiently in pulverized form than on stokers. A careful study of the facts in the case, however, does not bear out these statements. Stokers are burning a much wider range of coals than have ever been burned in pulverized form. Figure II gives an approximate analysis of 100 coals burned in 100 stoker plants in the United States and Canada.

Tests have just been completed on a 1000 H. P. boiler equipped with a 33 tuyere rotary ash discharge underfeed stoker. An average of 350% of rating with peaks of 400% was maintained for 60 hours continuously, burning a low grade of Illinois coal, of the following analysis:

6.71%	Moisture
36.41	Volatile matter
38.52	Fixed Carbon
18.36	Ash
4.6%	Sulphur
10,576	B. T. U. per lb. as fired

Fusing temperature of ash 1990 deg.

An average boiler rating of 375% was maintained on a similar test burning Iowa coal having a heating value of 9200 B. T. U. per lb. with an analysis given below:

13.4%	Moisture
33.1	Volatile matter
32.8	Fixed Carbon
20.7	Ash
6.85	Sulphur

Fusing temperature of ash 1920° F.

The CO_2 was high, with very little combustible in the refuse discharged from the ash pit. Solid refractory walls were used, with a small water back in the bridge wall. The furnace volume was 5 cu. ft. per rated boiler horse power. When we compare these results with the Peoria pulverized coal plant, for example, where the furnace volume is double that of a stoker plant, and where ratings such as we have mentioned cannot possibly be maintained, it is quite apparent that Mr. Daniels' and Mr. Savage's statements are not supported by substantial evidence.

It is interesting to note the fact that three plants in the United States, during regular operation have generated a kilowatt hour on one pound of good coal. These three plants are Crawford Avenue, Edgar, and Philo: all stoker fired plants. The designers of these three plants have selected stokers in every case, after a thorough investigation of powdered coal.

Chain Drive vs. Shaft and Gears

Unique among newspaper press drives is that recently installed in the press of The Milwaukee Journal and believed to be the only one of its kind in operation.

The shaft driven equipment originally installed was not satisfactory because of excessive friction. This was due, partly to the peculiar construction of the drive, and partly to the lack of head room for suspending the motors.

About six months ago The Journal replaced the shaft and gears with a chain drive, which has proved most satisfactory in every way. There are four 100-horsepower motors, each of which drives a sextuple press. The original drive was from the motor to a jack shaft, into a vertical shaft, then into a horizontal shaft. The present drive is by means of a 10-inch wide chain belt, 128-inch centers, making the total length of chain twenty-four feet. By adopting this chain, three sets of gears have been eliminated in each drive, or a total of twenty-four gears.

Engineers ordinarily hesitate to adopt a chain of this type because of the terrific speed with which it must work. The Journal, however, has found that, through the new arrangement, the operation is much smoother, practically noiseless, consumes less power and is more satisfactory in every detail. Since the adoption of the new drive, less than five per cent as much oil and grease for lubrication is consumed, one man has been eliminated and current consumption is materially less.

Conservation of Power in Industrial Plants

Discussed at a Meeting Held February 16, 1926, at the

Engineers Club of Philadelphia

Concluded from page 252 of the September issue

Operating a Private Power Plant in Competition With Purchased Power

By T. V. BALCH,
Supervising Engineer of the Equitable Bldg.,
New York

OPERATING a power plant is a highly specialized business. Most plants have the public service companies as direct competitors. Obviously it is impossible to run such a business without keeping competitors in mind and trying to do as well as they do in every detail.

The scope of this paper does not permit of many generalities. It will try to present in a brief form one system of operating a combined plant, generating electric energy and steam for servicing a large high class office building. Possibly there will be a few innovations applicable to other plants. A few comparisons with other operating policies are made only for the sake of explanation. It is always well to try particularly hard to overcome general faults.

The Plant

The Equitable Building plant has seven Heine boilers, total capacity 3,350 B.h.p., without superheaters or economizers. Steam pressure is 150 lbs. and feed-water is heated in an open type feed-water heater. The plant is equipped to burn either oil or hand fired coal. The engines are Rice and Sargeant Corliss, simple, made by Providence Engineering Co. They are direct connected to G. E. generators, 100 r.p.m., 240 volts, total capacity 2600 K.W., distributing current on a three-wire system with balancer sets. The auxiliaries include house pumps, air compressors, vacuum pumps, one hydraulic elevator pump and two 50 ton Carbondale absorption ice machines.

While this description is rather sketchy, it may give some idea of the size of the plant.

"Safety First"

Naturally the most important operating policy is insurance against breakdown. Everything else must be subordinated to that. Unless uninterrupted service can be maintained, a private plant can not hope to compete with public utilities.

To insure against breakdown means never to take a chance in the interests of economy. All maintenance and repairs must be done with the thought of making the plant always better. If it is possible to put in a cross connection, do so; it may come in handy some day. Adequate fuel supply must be carried. At present the Equitable carries three weeks' oil supply and two weeks coal supply in storage and so is fairly safe against any fuel shortage.

It is impossible to say which of the next two factors is most important. They might be called personnel and technique. The first means securing real cooperation from every man in the plant and, the second, keeping up a system of metering and records that will not only reveal all losses but will also assure that the plant is operated under test conditions all the time. By securing this cooperation the "mystery man" found in so many plants is eliminated. There is no one who can make alibis and be sure he can not be refuted. Every man in the plant has a voice and an interest in its operation.

A Unique Plan

This is accomplished in a unique way. Each week all licensed engineers, which includes day engineer, boiler room engineer, refrigeration engineer and two watch engineers, meet with the supervising engineer and the operating manager. Occasionally, the president attends these conferences. Extra time and traveling expenses are paid to the night men who have to make a special trip. While these meetings have been held for a little less than a year, the results have been astonishing. Although this committee is authorized only to make recommendations, its requests have always been granted. Some of the matters decided by them are applications for increases in salary, methods of making repairs and changes in operating methods. At these meetings, experiences in the different watches are exchanged, costs are compared and methods of improvement are discussed. Since their inception, every man in the plant has learned a great deal about the equipment and its operation and some of them had been on the job ten years. This cooperation of course spreads down the line. By means of a suggestion box, an oiler or coal passer can bring his ideas before the management and get credit for them. If an idea is adopted, the man gets paid for it. This plan, while unique in a power plant, is valuable in many ways, as it fosters co-operation, prevents duplication of mistakes, serves as an up-to-date school of experience and eliminates all possibility of the existence of an "Autocrat of the Engine Room."

For the benefit of all employes working conditions are kept as good as possible. Adequate lighting, good ventilation, proper toilet facilities and shower-baths and individual steel lockers are all provided. Compare this with the dingy hole so often used as an engine room. Everything is kept as clean as a hospital and, in order to act as an incentive to more work on the part of engineers and the more intelligent men, roustabouts are hired to do nothing but clean up. If a man has to clean up after himself, he is cautious about starting a dirty job. Light muslin stockings about thirty inches in diameter are provided to fasten to air supply ducts so that working conditions in any hot corner may be made comfortable during a repair job.

Importance of Metering

While the matter of keeping all employees happy is important, keeping up a metering system is equally important as a factor in economical operation; as a matter of fact, it is more important as far as the owners' pocketbook is concerned. The policy of a properly managed plant should be to operate on a test basis all the time. And that means that the best corps of engineers in the wide world could come in and not be able to carry the normal load any better than the ordinary crew in daily operation. If this paper were devoted wholly to this matter of accurate records, it would not be out of place; it is almost impossible to overstress their value. So the Equitable Plant maintains a most careful metering and record system. In comparing this policy of metering, which in this case is actually realized, with practice in other plants, two cases come to mind.

The first is of a plant where no engineers are welcome unless the chief is away. The manager of the property, being tactful, chooses a time when his chief is out to get any advice. He thinks things are being run very well except that too much fuel oil is being burned. The plant does cost about twice what it should to operate. The manager has nothing but commendation for his chief. He has just reduced the water consumption from 13,000 to 9,000 cubic feet a day, thereby saving four dollars daily. It was done by reseating the blow-down valve on one boiler! The very thought of fuel going out through a leaky water valve could not be comprehended by the manager. No wonder that plant costs double to operate. And they don't even know they can buy power and make a big saving. Or, what is more to the point, that they can operate the plant right and make a bigger saving.

The second case while not so flagrant is equally bad, as there are more of these plants. They admit that metering is the only policy but, in practice, they feel that meters are rather expensive to maintain and records a nuisance to compile; so they make a few guesses. For instance, in a number of plants, costs are all kept on the basis of a thousand pounds of steam. Fine, except that they don't measure the steam but assume an evaporation of 8½ because several tests have averaged this figure. And they can't understand why overall performances show the plant to be burning 8 or 9 lbs. of coal per K. W. H. instead of half that figure. Of course they are only getting the relation of the cost of labor, supplies, repairs, etc., to the pounds of coal paid for. How can fuel leaks show up?

Many plants operated in this way have been shut down and power purchased and almost all of them are sure to change unless they right-about-face and find out where they stand before it is too late. Public utility companies do not make these mistakes. The law requires published figures and, given the facts, the public service commissions would kick if the board of directors didn't.

How Meters Are Used

A brief description of the meters in use at the Equitable and the way they are maintained and the use made of them shows how much care is taken to insure accurate data. Fuel oil is measured by meters on each boiler and a daily check made by means of an inventory of deliveries and amount in supply tanks. A comparison of oil metered and inventoried does not reveal a difference of ½ of 1% a month. Total feed water is measured by means of a V-notch meter and the total must check the sum of the Bailey Boiler Meters. The difference is blow down and wetness in steam and is practically constant.

The steam distribution is very difficult to check because of the manner in which the piping is laid out. Boiler room auxiliaries, such as feed pumps, fuel oil pumps, oil heaters and steam atomizing burners, are not measured successfully. All other auxiliaries, however, are grouped and the steam metered. It is rather a simple matter to check any single unit simply by shutting it down and noting the difference in flow meter reading. While this check is rather rough, it is good enough. Live steam for heating is also measured so that it may be added to auxiliary steam, deducted from the total and the remainder charged against electric generation (including all boiler room uses).

The kilowatt-hours are measured by fourteen shunt-type meters on distribution to various light and power circuits. These are checked by means of recording ammeters on each engine which have proven such a source of trouble that they are being paralleled with Thompson watthour meters on each engine.

The methods of checking up steam for heating, and water distribution, are rather complex and, since they are applicable to this one plant only, need not be described.

Meters go wrong. In fact, they are always wrong to a greater or less degree and require constant attention. They get it, but the rule is not to correct any meter until the factor for correction of past performance has been determined. Because, after all *all records are comparative and the only reason for absolute accuracy is to check results in other plants.*

One Month

There follows a brief description of the salient features in the operation of each department and the records of that department for the month of January, 1926. That month is chosen only because it is the most up-to-date.

BOILER ROOM. A high daily peak and low night load requires cutting boilers in and out quite often. Experience has shown that about 125% rating is the best point to carry them and they are cut in and out on this schedule.

The Bailey Boiler Meters are set to give about 20% excess air. The original settings of these meters are made by means of an orsat. Check tests show that, with oil fires and high combustion chambers, it is possible to operate day in and day out with well over 14% CO_2 and no CO. Actual measurement of the air for combustion by means of an anemometer gives a very close check. Still, with all the meters that can be hung on a boiler, it is easy to make it smoke if the burners get out of balance. One burner may have too much atomizing steam and the next not enough. The whole question goes right back to the fireman's eye and his judgment of the fire. While burners and dampers are being regulated at the front of the boiler, conditions may be changing so that, by the time the fireman gets around to the rear to look in the peephole, conditions are different. So a system of mirrors has been installed and the fireman can get a good idea of the color of each flame while he still has his hand on the regulating valve. They have proved just about as useful on a boiler as a rear view mirror is on an automobile.

The most distinctive feature of the boiler settings is the arch. Instead of using a flat front arch, they are made in Gothic form. Standard blocks and wedge brick are used and they look as if they would never slump.

Feed water is treated with soda ash, an analysis of each boiler being made every day. Not only are the boilers kept clean by this but in addition the blowdowns are reduced to an absolute minimum.

The most novel feature of the boiler room is the method of preheating air for combustion. Space limitations and initial cost preclude the use of flue gas, so atmospheric steam is used. The only practicable form of heater is the automobile radiator as it is cheapest, takes least space, has the lowest draft loss and gives the highest heat exchange of any known type of heater. They are installed in the ashpit doors and heat the air to about 160° F. The first installation was made last September and has already paid for itself three times. With oil fires and low excess air, they save almost 4% and with coal fires should do much better. Here is one place where the non-condensing plant can get ahead of the central station.

During January, the boiler room was charged with 251,120 gals. of oil purchased as 18,200 B. T. U. per lb. Steam credited, including that used by all boiler room auxiliaries except the soot blowers, was 30,370,000 lbs. The average monthly efficiency, including boiler, furnace and air heater, was 82%. That may sound high but, if the oil is too low, the oil company is giving something away. And, if the steam is too high, the rest of the plant will show a poor efficiency. The stack loss, with, let us say, 20 lbs. of air per lb. of oil, from 150° to 490°, is only 9½% and certainly standby, radiation, etc., have no reason to be more than 8%. High boiler efficiency is attainable not only on test but may be realized also under average performance.

AUXILIARIES including vacuum pumps, brine and ammonia pumps, drip pumps and air compressors used only 1,806,000 lbs. of steam, or about 6% of the total generated. This is a reasonable figure, although these auxiliaries are carried against a high back pressure to operate the absorption refrigerating plant and this part of the system is about as nice a study in heat balance as it is possible to make. As a whole, it might be considered that the use of steam is more than 100% as the exhaust is all condensed in the ice machine and cooled below feed water temperature. This sounds like ideal condition for any plant but, as an example of how deceptive this matter of heat balance can be, let us consider it from another angle.

These auxiliaries now use about 1,500,000 lbs. steam a month. They can easily be replaced with electric auxiliaries requiring about 40% of that figure, or about 600,000 lbs. per month, in the engine room to produce the electricity. Of course the ice machine will still need 1,500,000 lbs. and it would not be reasonable to carry the main units on a back pressure to supply it. But it may be done by using high pressure steam to operate an injector and pick up atmospheric steam. In this way 400,000 lbs. of 150 lb. steam will pick up 1,100,000 lbs. of atmospheric steam and supply the needed 1,500,000 lbs. of 10 lb. steam. In this way the live steam consumption of the auxiliary system may be reduced from 1.5 million to 1 million. And this system, which already has an efficiency of 100% on the basis of output against live steam consumption, will have an efficiency of possibly 150% on the same basis.

It is possible, however, to still further improve in another manner. Carry these auxiliaries under 30 lb. back pressure and utilize 90% of the exhaust for restaurant steam. Then carry the ice machine load on live steam by means of the injector principle. In this way the expense of converting auxiliaries to electric drive is eliminated.

These three examples of heat balance are brought forward only to show that it is almost impossible to make any generalities or to specify for any particular problem without complete data on everything involved. The only rule that can be laid down is to attempt to utilize all the exhaust steam possible.

Steam vs. Electricity

Generally speaking it pays to replace all steam auxiliaries with electric. They save considerable money in fuel, due to higher efficiency and better control and the expense of keeping steam up to the throttle is eliminated. They are just as reliable as steam since, in case of loss of voltage, they need not be run as they are not much use with no light or elevator power. Of course this does not apply to the boiler feed pump.

A fair example of possible savings along this line is a recent conversion of house pumps. The job cost about $6,000 but has already paid for itself.

THE ENGINE ROOM, although the largest steam user, is the easiest problem for the operating engineer. Generation for January was 573,000 K.W.H. against which is charged 20,740,000 lbs. steam. This is total steam, less auxiliary steam and live steam for heating. It includes all boiler room usage, header and separator losses as well as engine consumption. On this basis, the steam consumption is about 35.6 lbs. per delivered K.W.H. If 4% of the total is subtracted for boiler room usage, the actual engine consumption becomes only 33.5 lbs. per K.W.H. or 22.4 lbs. per I.H.P. hour. Since this is a net over-all figure and includes all pipe and separator losses, it compares very favorably with the makers' guarantee. It is profitable to indicate the engines regularly and to test them for most efficient loading. Once everything is running right, the check provided by the daily log sheets will show any variation from normal.

Where Are the Losses?

Granting that it is possible for a plant to operate with all equipment very close to its maximum efficiency, why is it that most plants do not? Where are the losses?

Usually they are not visible. The ash pile represents a source of loss but it is not possible to send very much fuel out of the building that way. Nor is there much steam lost through visible leaks, they would have to be too large.

There are three large sources of loss and they are all easy to check up.

The first is the stack. This is most important but has been treated so many times that nothing need be said.

The second is the air. This includes loss of heat through bad insulation and excess exhaust.

But the most neglected factor is the vapor lines. As a sample of what may be done with these, the clean drip vent is gagged* at the Equitable and the vapor condensed in the air heaters on the boilers. This vapor is worth saving as it serves to preheat the air without any aid. Some such check as this will prove a great help in finding bad traps.

The third source of loss is the sewer. No one ever looks at the sewage or tries to measure it. No wonder so much avoidable waste goes out that way. Of course the fuel goes out as heat; it isn't hard to locate those leaks. Water, however, is a rather important item and, since it usually comes within the province of the engineer, it would not be out of place to touch on it. Possibly the first thing to do is test the city water meters; it does not take long and may prove valuable. The next thing is to find a method of measuring all distribution. If this is not practicable, it is always possible to shut off house pumps at night and measure the rate of fall of the tank. If this is done often, a leaky bleeder valve at the foot of a riser won't have much chance to run up the water bill.

Possibly the simplest and cheapest method of testing house water is to put a kilowatt hour meter on the pump. The factor for conversion into cubic feet is readily found by test of the pump. By using a recording ammeter it is always possible to account for increased power consumption. If the pump starts oftener the water usage has increased; if it runs longer its efficiency is falling off and it needs new wearing rings.

Possibly a word on the design of plants from the viewpoint of the operator would not be amiss.

The first point to bear in mind is that the plant will not run itself; men have to work there all the time. Conditions should be as comfortable as is reasonably possible and facilities should be provided for handling materials expeditiously. If the only access is by an iron ladder and every barrel has to come in or out on a block and fall, labor costs are going to be high and men hard to keep.

Can We Do Better?

The design of plants has not changed very much in the last twenty-five years. Possibly a building plant laid out somewhat differently from the ordinary would be not only cheaper but also more efficient.

A building plant generally has a poor load factor; let us say .35. This load may divide among four types of units, each capable of carrying one-third the peak load.

The first third may be run to a yearly load factor of about .90. Obviously this equipment may be more efficient than the rest of the plant. It will pay to put an economizer on this boiler or possibly an air heater. The engine to carry this base load must also be efficient, let us say a compound.

The second third of the load will come possibly only ten hours per day. This equipment will be breakdown for the first equipment and will not need to be so efficient, as its load factor is much lower. Possibly this is the place for a unaflow engine since it will have to carry the fluctuation as the peak is coming on and going off and will need a flat efficiency curve.

The third division of equipment will have to carry only the daily peak.

The last section is for breakdown only. Anything at all that will run would seem to satisfy this condition.

This may sound rather fanciful but almost every good operating man makes changes in the plant as it is turned over to him and eventually arrives at this condition to a greater or less degree. And of what use is uniformity of equipment? About the only interchangeable parts in an engine room are the governor springs.

Another essential feature is a well valved header loop. It should be arranged so that any one section could fail and the plant still be operated.

All auxiliary steam should be carried through a single line, cross connected of course, and a meter provided.

House auxiliaries should all be electric drive except for one fire pump and one boiler feed pump, possibly both. Electric drive is just as reliable as steam and is always more efficient for small units.

This plant, if properly laid out and erected, should be able to compete much more favorably with the power and steam companies than most of the plants now making a success of it.

How will total yearly costs average up when compared with purchased service? That depends of course on the size of the plant. It is no violation of confidence to state that the Equitable plant is now operating for about $100,000 per year less than purchased service. Without a somewhat lengthy analysis of figures and considerable explanation it is not possible to prove just what percentage profit this actually is.

However, as long as the power plant can make a larger profit in competition with the public utilities than the building or factory it is serving can make in competition with its competitors, there will be a field for the isolated plant.

DISCUSSION

JAMES A. McHOLLAN, Consulting Engineer, New York. It is somewhat of a handicap to follow Mr. Bolton and Mr. Balch on this subject, but I would like to pay a tribute to Mr. Balch as to his knowledge of the power plant in the Equitable Building which is under his charge. About a year or two ago, one of our clients asked us to make an examination of that plant. I then had the pleasure of meeting Mr. Balch and of examining the equipment under his charge. It is a model installation, most efficiently operated and supervised.

On this question of operating power plants, as compared with purchasing electric service from central stations, engineers must always keep in mind that the men who finally decide this question are those who finance the construction of the buildings. My experience is that, in new buildings today, even in the largest, when you consider the fixed charges on the investment for machinery, the installation of a private power plant cannot be justified. In existing buildings, where the installation has already been made, the operation of about one out of ten is justified.

In New York the private power plants in existing buildings are being abandoned at the rate of about 70 per year. For one department store in New York whose plant was installed about eight years ago, we prepared plans and specifications for economic operation with purchased electricity. The owners spent $90,000 to electrify the steam-driven machinery and the saving with purchased power is $50,000 per year as compared with former costs of operating their private plant. As a result of this demonstration a large store in Philadelphia is proceeding with similar changes.

The Equitable Building is the largest of its kind in New York, but the investment for power plant machinery has already been made. The new New York Telephone Building is almost as large as the Equitable Building; but it has been decided to use central station service and omit the investment for power plant equipment.

Now we may talk and figure and discuss heat balance, British thermal units, heat content and such matters, but the final fact remains that it takes about 300 tons per million cubic feet per year to heat an office building in this part of the country. If you are operating an office building of 10,000,000 cubic feet, you can heat that building with 3,000 tons of coal

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*The clean drip has a relief valve set at about 3 pounds so the vapor cannot blow freely into the atmosphere.

per year. The coal required to heat buildings is a known quantity, depending on the outside temperature. I want to make this point clear about the fuel required to heat large buildings because that is where the controversy centers between the private plant and the central station. The value of exhaust steam has been overestimated in the past. I want to repeat again my remarks about fuel used for building heating. Everybody overestimates the coal required for heating. The actual figures are: Office buildings, 300 tons per million cubic feet per year; hotels, 450 tons per million cubic feet per year, and for a factory, 250 tons. By keeping those figures in our minds and remembering that our clients, the owners, will insist on considering fixed charges on the cost of power machinery, it will be clear why private power plants are no longer being installed in new structures and why they are being abandoned in old buildings. I feel that the displacement of private power plants with central station service is of financial benefit to real estate and is a real contribution to progress and economy in American industry.

J. K. M. HARRISON, New York. I am particularly interested in the actual yearly cost of operating comparative buildings, or the same buildings, with a private power plant and with purchased power. Figures taken over a period of years are the real results that interest the building owners. To them BTU's per pound of coal, or Kilowatt hours per pound of steam, mean but little, but when you can show them that a building has cost so much to operate with a private power plant, and it costs so much to operate with purchased power, over periods of not less than one year's time, then you have their interest and can give them data of comparable value.

I am more familiar with the comparative costs of furnishing light, heat and power services in buildings in Philadelphia than I am with the conditions in New York City. Of the information available on the Equitable Building, the most interesting figure to me, is that their Kilowatt hour consumption per year is in the neighborhood of 7,000,000 Kilowatt hours. In New York City, according to their present rates for purchased power, the cost would be approximately $150,000. In Philadelphia, the cost of the same current, assuming a normal maximum demand for such a load, would be approximately $80,000 a year. This difference of $70,000 would go a long way towards offsetting the saving of $100,000 claimed by Mr. Balch for the private power plant in the Equitable Building, as against the use of purchased power in New York City.

It has been my experience that universally the private power plant decreases in its overall operating efficiency from year to year. An examination of the yearly cost records of these plants, for a number of years, confirms this. On the other hand, the increases in efficiency of the large public service plants, due to the constant addition of more modern generating units, reduces the cost of the power so that the buildings and industrial plants making use of purchased power in Philadelphia, have seen their cost of power reduced nearly every year, owing to the lowering of rates for this power by the Philadelphia Electric Company.

I should like to add that, to my mind, discussion or argument on purchased power versus private power plant is useless, and no results can come of the same unless the comparative figures on identical building, or plant, conditions are available over periods of at least a year. Individual analysis of detail costs, taken on any other basis, will end only in futile argument.

As is well known, figures can often be made to show any result desired, and this is particularly so in attempts to analyze power costs in private power plants. On the other hand, yearly comparative costs on similar buildings permit the drawing of conclusions that cannot be refuted.

ARTHUR H. ALLEN, Philadelphia. There are one or two points on this central station versus isolated power plant which I should like to present. I have been listening to the very able papers and discussion on extremely large power plants running into millions of kilowatt hours consumption, but the question of the smaller plants has not been discussed or considered. I am not one of those who would stand here and claim that all industrial power plants shall be isolated nor that all industrial plants should receive their current from central stations. I think there is a happy medium.

I am speaking now more particularly of industrial plants as distinctive from department stores, hotels and large buildings. There are many industrial plants that are operating motors and whose aggregate motor capacity could be cut in half. In other words, these plants are improperly motored. That has been emphasized and brought out very strongly by the central station companies themselves. They are now stressing greater efficiency in motor application; they are emphasizing the fact of higher power factors, and they have an exceedingly excellent corps of engineers. If the owner of an industrial plant applies the same engineering ability in proper motor application of the motors in his plant, many of our plants could generate their power just as economically as can be furnished by the central station companies. If the industrial plants—many of them—employed power factor correction in their plants, they could reduce their generating plant. It has been demonstrated that a great many plants are operating under 40 per cent or 50 per cent power factor, which means large generating units which can be cut in half if improved power factor apparatus is applied to that motor installation.

That makes an entirely different proposition for the central station man to come in and show the owner of that industrial plant where it is economy for him to shut down his power plant, particularly if he has use for steam as a by-product.

The trouble is—and I am speaking now to the owners of plants and the engineers here who are operating individual plants—that you will allow the central station companies to come along and put something over on you. If you just apply the same engineering to your own plant—and if we are not capable of doing it, for Heaven's sake get someone who is capable—you will find an entirely different proposition for the central station companies to butt against.

The central station companies, of course, are here; they are going to extend; they are going to shut down a lot of plants, but there is a happy medium, in my estimation, above which the industrial plant is not justified in getting outside or central station power.

T. V. BALCH, New York City: The paper which I was asked to present was to be on the operation of a private power plant.* I should like to supplement it somewhat with one or two remarks on the factors governing their existence.

First as to some of the large buildings recently erected in New York without power plants. The new Telephone Building on West Street has been mentioned. Here space seemed readily available. By putting a coffer dam down all around and dredging out the silt something like five basements were excavated very cheaply. However, I have been told that all this underground space is already filled with mechanical equipment and even more room is needed. Naturally no space could be spared for a power plant. One on Park Avenue went up without even a heating plant. This is a very large building. Many buildings are being built today on a shoe string and the owner can not borrow another nickel to put in a power plant if he wants to. With borrowed money and an increased gamble, inasmuch as the plant does not begin to pay until the building is nearly all occupied, there have been many buildings put up without plants.

I admit that there have also been many plants shut down. But I think that nine times out of ten they have been shut down either because they were run down and obsolete or because the operation was so poor and waste so bad that costs were excessive.

Let me give an example of what is possibly a different way of working out the financial status of a building power plant. In this case the owner, a successful business man, wants to realize what looks like 40% return on the plant investment. He asks 20% for depreciation and another 20% for entering a risky business. He is not in the power business, but the hotel business, and does not want to go into the power business unless it is worth his while. While these arguments sound like those of the power companies they are not all propaganda, but exceedingly sound in many ways.

The first 20% is for the purpose of amortizing the investment in five years. The reason is that with the rate of present technical development, as evidenced by the recent almost universal adoption of the electric refrigerating plant, or the power project of the State of Maine in Passamaquody Bay, five years hence power may be so cheap that the plant will have to be scrapped. While both these instances may be explained away, still there is something in this argument. The second 20% is for entering a risky business, and undertaking all the nuisance and twaddle of a power plant on the premises. This is also rather high but is still a good argument.

Here is a method of computing the return from a plant to meet both of these conditions.

First, the stack is considered as essential. Without a stack a building is always at the mercy of street services. Rent cannot be charged for the space, as this provision is only sound insurance.

Second, the heating problem must be considered alone. Will a low pressure plant pay? Generally speaking it does, inasmuch as it will burn no more coal than the steam company and will have no investment and maintenance of street lines. This in spite of the fact that the street steam company is satisfied with a low rate of interest on its investment, whereas the owner of a plant wants a high rate.

The electrical plant must be considered then only in the light of its extra cost above that of a low pressure plant. It is then more nearly fair to charge a high rate of depreciation if it only be charged against the engines and generators, but not against the boiler plant.

A fairly large plant worked out along these lines makes a most satisfactory showing—the conditions are met that the plant pays for itself in five years and makes the necessary profit as well.

While this phase of the power situation is possibly out of my line, being an operator and not a consulting engineer, still I hated to let this opportunity go by without presenting these points.

W. G. DINAN, Supt. of Power, Amoskeag Mfg. Co., Manchester, N. H. It is rather difficult to compare costs without a knowledge of the various items entering into the total operation such as fuel, oil, waste, repairs, labor, insurance, taxes, management, distribution, maintenance, depreciation, payment of dividends and profit. The size of the plant, load factor, variation in load, ratio of maximum load to the economical full load, number of days the plant is operated, etc., must be known to make a true comparison. In estimating the cost of power, a clear distinction must be made between the cost at the bus bars and the cost delivered to the customer. The former cost should be based on only such portions of the charges and expenses as are applicable to the generating station. While for the cost of power delivered, the total expenses must be considered and, in any plant, this must be taken as the final cost of the K. W. hour produced.

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*See page 269.

What can be compared, however, are the general average cost of public service current, as at present sold and delivered, and the production cost of industrial current. We hear a great deal today of how cheap the public service plant can generate current and sell it. In some cases it is true, this can be furnished cheaper than the industrial plant can generate it. A great deal, however, depends upon the type of the industrial plant and its relative demands for power and process steam. As soon as any by-product steam is used for manufacturing purposes or heating, or any hot water is required for processing, the central station will be at a disadvantage. In comparing a public service plant and an industrial plant, the total operating costs are seldom taken into consideration. The public utility's sale price is generally compared with the cost to produce power in an industrial plant which does not, of course, show relative costs. I should much prefer to see comparisons between the actual total operating costs of the two classes of plants. Under those conditions, it will, in many cases, be shown that the industrial plant is sold power much cheaper than it has any right to get it.

One of the present needs today is to arrive at the true facts in regard to power costs. In this country it has not been the general practice to publish these details and there still exists a prejudice against publishing cost data. It is only natural that utilities do not care to divulge their true performance figures, but why should the engineering profession be made the loser because of a condition that can be overcome? There is real need of education concerning the basis of rate making. Few people have the slightest idea of what elements enter into the determination of a just and equitable rate for light and power service. It is, therefore, impossible to make any comparisons, and the engineering profession is as much in the dark with public service costs as it is with industrial costs. When considering the operation costs of a public service plant, all items should be taken into consideration and the cost per K. W. H. should be figured from the current sold. A certain part of the K. W. H. produced goes into the plant itself, and a part is lost in distribution, so that the actual cost should be figured on the K. W. H. sold. Current lost in generation and distribution is a part of the manufacturing process and the current delivered is the finished product. From fifteen steam driven public service plants, I have obtained figures which show that the current sold per year was 1,453,924,986 K. W. hours at a total operation expense of $31,111,130. This makes the actual reported cost per K.W. hour of sold current 2.14 cents. While this figure may be thought high, I believe the average central station, with all costs taken into consideration, will not be below 2 cents and this figure rarely appears in reports. A public service plant has to carry all the charges and profit of a business organization and its manufactured product is power. An industrial plant is only a part of a larger industrial organization and charges against it are only those properly included in the generation of the power alone. Of course, there is no allowance for profits or dividends and the depreciation is proportionately less. Also line distribution and transformer loss, chargeable to the public service station before the current is sold, is no small item. This does not, in general, occur to such an extent in an industrial plant. In a public service not much over 80% of the power generated is delivered to the customer; the remainder is lost. In New York for the year 1924, there were generated 7,524,241,845 K.W. hours. During the same period there were sold 6,019,459,504 K.W. hours. This shows a loss from generation to sales of 1,504,792,341 K. W. hours, or nearly 20%, which, of course, has cost money for production and would probably average at least one-half cent per K.W. hour or more.

In these notes, I am not considering public service sales prices. While it is possible, under existing regulations, for them to make low rates in order to increase their load factor and for other reasons, I think many industrial plants can compare favorably when all costs are taken into consideration. Public service current is sold in many cases for less than cost. This, to my mind, is unfair and basically wrong. Industries can and would install their own plants and discontinue purchased power, if charged their proper proportions of public service overhead and profit. The small user cannot do this, so must bear the burden. I do not think a public service should be allowed to sell current at less than cost. When this is done the deficiency must be made up by other schedules which are, therefore, higher than they should be. It may be good business for public service plants to do this. There is too much spread between 1 cent per unit and 10 cents per unit for exactly the same amount and kind of current. There should be fluctuating rates depending on the current used, but the retailer should not be made to pay for deficiencies caused by selling current at less than the cost of manufacture.

I should like to see actual cost figures brought out by a properly selected and unbiased committee. This would, of course, be a rather difficult thing to do, unless there is favorable cooperation on everybody's part. I want it understood that these notes are written with no idea of restricting the economical use of purchased power. Central plants have been the forerunners in engineering improvements, effecting the economical operation of boilers and turbines. They are an asset for the community and the nation. What I do, however, want to bring out strongly is the question of costs, which, to my mind, are unfair at the present time. Comparisons between plants should be made only when all costs in connection with the production of power are taken into consideration. If this is done, it will be found that there is a marked difference between the costs used as a comparison, and the actual costs.

Industrial Progress and the Engineer

THROUGH the improvement in organization and in productive methods rendered industry by technically trained men, marked increases in industrial efficiency have been brought about. In the steel industry, for instance, 2 men with modern unloading machinery have replaced 12 to 20 unloading by hand; in blast furnace charging 2 men using machinery do the work of 14; in pig iron casting 7 men accomplish what 60 formerly could do, and in the unloading of scrap and pig 2 men with great electric magnets and traveling cranes get done in a day as much as 128 working under old methods.

Greater productive capacity exists in virtually every industry—in textile, tire, steel, oil, shoe, leather and others. Herbert Hoover has estimated that while the number of wage earners in American factories increased 27 percent in the last 10 years, their output, in terms of quantity, increased nearly 60 percent. Production per wage earner employed has advanced by at least 25 percent.

These figures are indicative of a great new trend —the flow of technical knowledge, from the engineer and scientist, to business and industry. Increased production has come about very largely through the adaptation, by the engineer, of research in pure science to practical needs.

How has this new knowledge—these new methods —reached the business man? In two important ways this new technique has spread to the industrial world. Where size and resources have permitted, business has set up its own laboratories and engaged its own staff of scientists and technicians. Or, this knowledge has been secured through the medium of books, scientific journals, the reports of technical societies and their bulletins and publications.

This latter is important for two reasons. First, every industry cannot maintain its own laboratory and staff of engineers. Secondly, a wide diffusion of knowledge is constantly necessary to avoid costly duplication of research and, assure to industry as a whole the benefits of the latest and best scientific knowledge.

A valuable channel for this dissemination is the American public library. Indeed, one of the principal directions of recent library growth has been in the development of Science, Technology and Economics departments. Yet despite the rapidity with which the engineer and his contributions have been utilized by industry and business, there exists today, unapplied and ofttimes unknown, vast aggregations of technical knowledge. Engineers have asserted that technical knowledge is available which would go a long way toward the abolition of poverty, double or treble the standard of living, change ugly cities into noble ones, and by the means of electric power and decentralization bring the culture of the town to the countryside.

Fully one-half of the million man-years lost every year through industrial accidents could be saved if our engineering knowledge were generally known and applied.

Much technical knowledge must, of course, remain unused for a considerable period of time, for its application would mean the scrapping of many large industrial units. Application must come about gradually. Yet, there is a danger that valuable technical knowledge which might be immediately useful will remain buried in brochures, locked in laboratory reports, or stand on shelves, unknown. Progress in industry rests not only upon the creation of new knowledge but also upon its diffusion.

Engaged in a general program for the spread of knowledge is the American Library Association, a national body of 8,400 libraries, librarians and allied organizations throughout the country.

It is engaged in bringing industry and business into closer contact with the sources of technical information. Its program includes the establishment and development of Science, Technology and Economics divisions in the public libraries.

Its knowledge and experience in all the ramifications of library work is placed at the disposal of corporations, of business and scientific organizations. The Association is engaged in pointing out the growing technical resources of the public library and the many sources of technical information to which it holds a key. It is endeavoring to make the public library a vital medium between science and industry.

Such a program will require, however, the co-operation of the engineer, of business and industry, for its accomplishment. The Association, whose headquarters are at 86 East Randolph Street, Chicago, asks therefore that all organizations and publications concerned in decreasing the actual physical burden upon the American people, in the dimunition of the average hours of labor and an increase in the standards of American living, co-operate with it in this work.

The Engineer in Politics

By GEORGE H. DERN

Governor of Utah

IF THE engineer is to go into politics, as I think he should, I believe the curriculum of every engineering school should be amended to include a good stiff course in public speaking. My observation has been that the engineer in private conversation can scintillate as brightly as a life insurance agent or an oil stock salesman, but before an audience, with rare exceptions, he is a total loss. He will not get up and talk. He hides his light under a bushel, and sits on the bushel as dumb as an oyster. I have attended meetings at which some topic of general interest to the members was up for discussion, and where an animated debate was the logical thing to expect. After the chairman states the subject and invites discussion, there is dense silence. Finally a member, bolder than the rest gets up and, with trembling voice and knees, makes a motion. The motion carries, the meeting adjourns, and then the members gather into groups and begin to discuss the question seriously and intelligently, giving cogent arguments on either side and embellishing their remarks with appropriate or inappropriate epithets, illustrations and figures of speech.

Now, I am not pleading for more speechmaking. The good Lord knows we have too much of this great American indoor sport already. But I think every man ought to be able and ready to express his opinions at the proper time. Some men have a reputation for wisdom because they do not talk much. We speak of the wise old owl because she never speaks, but in my opinion the owl's reputation for wisdom is vastly overrated. Silence is more apt to be a cloak for stupidity than for wisdom. The person who has ideas cannot exert any influence by keeping them locked up in his own mind. The great motive force of the world is not muscle, but ideas, and ideas in order to get in their work must be released.

The engineer, with his training of observation and analysis, ought to and does have ideas, and usually they are sound because they are founded upon facts and are carefully reasoned out. The world needs his ideas, and he ought to be equipped to express them at the time and place where they will do the most good. Perhaps I am presumptuous in urging engineers to be more vocal, but I think this recommendation has a direct bearing on my subject.

Politics is the science of government, and government is the science of human relationships. In other words, politics has to do with people. So long as the engineer remains in his own profession he has to deal almost exclusively with things—with inanimate matter. I was going to say cold, inanimate matter, but as a matter of fact inanimate matter is not always cold, as smeltermen and electricians know. But when he gets into politics he has to deal with living, breathing human beings. He must know something about how the human mind operates. He finds he cannot do anything for the public unless the public believes in him. He must sell himself to the public before they will follow his lead.

This is an age of specialists, and since engineering and politics are concerned with such different kinds of materials, it has come to pass that engineering is one specialty, and politics is another, and it is only occasionally that the engineer, in a dilettante fashion, becomes active in politics. Possibly that is the first reason why the engineer in politics is conspicuous by his absence.

I attended a meeting of the Engineering Council of Utah the other day, at which 200 engineers were gathered together, and as I looked over that company, I saw few who would know what to do if by chance they should get into a primary or a convention. All of them were highly intelligent and highly educated, but they were innocent babes when it came to playing the gentle game of politics. The reason is that they do not play the game. It takes practice to become proficient in politics just as it takes practice to become proficient in golf.

Why doesn't the engineer participate in politics? I suppose one reason is that he is too busy trying to make a living, and the fees in politics are not overly tempting. I am afraid, therefore, that I should be giving engineers bad advice if I advised them to go into politics for the money there is in it. However, it is well known that engineers do not care anything about money. All they want is a chance to serve their fellow man, and so I feel safe in urging them to go in for politics.

An intelligent study of any question is properly commenced with definitions of terms. What is an engineer, and what is politics? Dr. George Otis Smith made the statement that an engineer is first of all a fact finder. I agree with that, and add that he must be willing to act in accordance with the facts as he finds them.

NEW BOOKS

BOOK REVIEWS

Social Classes in Post-War Europe—By Lothrop Stoddard. $2.00.

"Looking backward athwart the course of human history, we observe that every new epoch has been characterized by marked class changes, often of extreme rapidity and intensity. . . . The Great War marks the beginning of a new epoch as definitely as did the fall of the Roman Empire, the discovery of America, or the advent of those novel economic forces a century ago usually termed 'the industrial revolution'.

"As might have been expected, this new epoch upon which we are entering is accompanied by notable class changes. They are discernible throughout the civilized world but they are most pronounced in Europe—the main theatre of the late conflict and hence the region most immediately affected by its consequences." —Lothrop Stoddard.

Racial Realities in Europe—By Lothrop Stoddard. $2.00.

The failure of Americans to understand Europe is due to a very fundamental misconception. We think of Europe in units of nations. We think of these nations as homogeneous. We take too little account of race and race mixtures. We cannot understand Europe until we know thoroughly its racial background. This is the thesis of Mr. Stoddard's absorbing book.

He begins, therefore, with a clear account of the distribution of races in Europe; what he calls the "racial realities." With this foundation, he examines the racial composition of the specific countries. Thus he explains their policies.

Great Britain is predominantly of one race, which accounts for the consistency of her policies. France is composed of all three of the European races, Nordic, Mediterranean, and Alpines. This often accounts for the nature of French policy and for its uncertainty. The change in Germany's character and policy is due to change in racial proportions.

Thus he examines the Alpine East, the Mediterranean South, the Balkan Flux, the Mongrel Levant.

In later chapters he applies these principles to America and from the entire situation draws conclusions of the utmost illumination and importance.

Transport Aviation—By Archibald Black, Air Transport Engineer. 254 pages, 107 illustrations, 5½x8½. $3.00.

Every year man moves more daringly through the air, developing his wings for the sake of adventure, faster postal services and commerce. Astounding records for safety, economy and speed have already been established.

This book is for the investor who is interested in promoting airlines, either present or prospective, in that it gives complete and accurate figures for all costs and returns in air transportation. It is also for the engineer in charge of operations, as it gives detailed technical data on every phase of equipment and upkeep, as well as much valuable information on design, operation and maintenance and finally, for any one who in any way has anything to do with transportation.

Scientific Humanism—By Lothrop Stoddard; 174 pages, 5x7½. $2.00.

A book which everyone should read and give thought to. Mr. Stoddard in his Foreword writes, "Are we entering a new age? Will we adjust ourselves to the new world which modern science has disclosed? Is there to be a new flowering of the mind and spirit quickened by the vast extensions of knowledge and power with which we have been endowed, as the Renaissance flowered in Humanism four centuries ago? Shall our present transition time with all its unparalleled possibilities for good and for ill culminate in a great civilization or in a great catastrophe?

"Such are the queries which today stir forward-looking minds. What the outcome will be, no one knows. Yet we may safely predict that the outcome will be largely determined by what we, of this transition epoch, think and do. To offer some suggestions for sound thought and action, this book has been written."

Structural Engineers' Handbook—Data for the design and construction of steel bridges and buildings—third edition, enlarged. By Milo S. Ketchum, C. E., M. Am. Soc. C. E., Dean of College of Engineering, University of Illinois; flexible, 6½x9, pp. 1,080—xvi; 275 tables and 450 illustrations. $7.00.

More than 130 pages of new material have been added. The most important additions are a chapter on "Self-supporting Steel Stacks"; properties and details of "Constant Dimension Steel Columns" and Steel Column Footings; revised specifications for steel mill buildings, steel office buildings, steel highway bridges, steel railway bridges and engineering materials. New data are given on mill buildings, office buildings, highway and railway bridges, retaining walls, stiff frames, and eccentric riveted joints. New properties of Carnegie and Bethlehem sections in Part II have been given, and the tables of properties of sections revisd.

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Accounting and Business Methods for Contractors—171 pages, pocket size, flexible. $2.50.

Sound, definite, dollars-and-cents business methods which have proved to be most successful in the author's long experience. Methods of time keeping, paying off, finding labor costs, finding material costs, keeping costs where they can be used properly—the common sense of cost-finding and cost-keeping as the practical contractor wants to know it. He does the same for accounting, purchasing office procedure, subcontract relations, insurance and banking. The material is all drawn from actual practice. The methods described have proved satisfactory. The book gives information that the contractor and construction manager concerned with the business side of contracting can use to advantage.

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Industrial Furnaces—W. Trinks, M. E. Consulting Engineer, Prof. Mech. Engineering, Carnegie Institute of Technology.

Volume I.—352 pp., 283 figures. $4.50.

As a whole, Volume I deals with the principles which underlie all industrial furnace operations and furnace design, and with those applications which are independent of the nature of the fuel or energy supply. Such subjects as *The Heating Capacity of Furnaces, The Fuel Economy of Furnaces, Heat-Saving Appliances in Combustion Furnaces, Strength and Durability of Furnaces,* and *Movement of Gases in Furnaces* are fully covered. The most important and outstanding developments made recently in the field of industrial furnaces are included as an appendix, thus bringing the volume up to date.

Volume II.—405 pp., 292 figures. $5.50.

Although a continuation of the first volume, this is complete in itself and is devoted primarily to practice. It will be found an invaluable reference book for (1) men who have to decide on the type of fuel or heat energy to be used in specific cases; (2) those who select furnace equipment; (3) sales engineers of furnace equipment; (4) men who install furnaces, and (5) furnace operators.

A great deal of equipment is described, and being the only treatise in existence on the subject, this book will find a wide usage in countries other than the United States.

Mathematics for Engineers—By Raymond W. Dull, Consulting Engineer. 780 pages, 5½x8. 686 illustrations. $5.00

A quick, convenient and reliable reference and text book for engineers who wish to review or extend their information on those phases of mathematics especially important in engineering work.

American Machinists' Handbook—New Fourth Edition. By Fred H. Colvin, Editor, American Machinist, and Frank A. Stanley, Editor, Stanley's Journal of Machinery. Total issue 220,000. Fourth Edition. 972 pages, 4x7, flexible, pocket size, illustrated. $4.00.

A revision of the most widely used technical book in the world. Every table and formula, every page of reference data has been brought up to date, and much new material added. The book is a complete and authoritative reference of machine-shop and drawing-room data, methods and definitions.

Steel Structures—Stresses in Simple Structures—By Leonard C. Urquhart, Professor in charge of Structural Engineering, Cornell University, and Charles E. O'Rourke, Assistant Professor of Structural Engineering, Cornell University. 278 pages, 6x9. 214 illustrations. $3.50.

The fundamentals of stress calculations in simple structures. Both graphical and analytical methods are shown in most cases. While the relation between graphical and analytical methods is emphasized, the methods have been separated so that each may be taken up separately. Both methods are illustrated by actual numerical problems.

Mathematics for the Practical Man—By George Howe, M. E. Explaining quickly and simply all the elements of Algebra, Geometry, Trigonometry, Coordinate Geometry and Calculus. 143 pages, 5x7½, 42 diagrams. $1.50.

No matter what problem you have to solve you'll find that you need a working knowledge of mathematics. The expert in your line knows how to handle figures. Algebra and even calculus are simple, if you go about things the right way. The application of common sense removes all the mystery and all the difficulties. Herein a treatment of mathematics along common sense lines.

Civil Aviation—A Report prepared by United States Department of Commerce and American Engineering Council. $2.50.

This official report was compiled by a committee of the leading experts on the several phases of the subject covered. Before it was released for publication it was reviewed in detail and approved by the highest officials of the Department of Commerce and by the Administrative Board of American Engineering Council.

Library of Engineering English. $8.00. Following 3 vols.

English for Engineers—By S. A. Harbarger, Department of English, Ohio State University. 260 pages, 5½x8. $2.00.

Composition of Technical Papers—By H. A. Watt, Professor of English, New York University, and P. B. McDonald, Assistant Professor of English, New York University. 429 pages, 5x8. $2.00.

English and Engineering—Edited by Frank Aydelotte, President of Swarthmore College. 415 pages, 5x7. $2.00.

Public Speaking for Business Men—By William G. Hoffman, Associate Professor of Public Speaking, Boston University. 300 pages, 5½x8. $2.50.

The above four books discuss the general principles of effective expression and then take up in detail the writing of technical descriptions, technical articles, engineers' reports and letters, and the principles and methods of talking convincingly and persuasively at business and professional meetings. They stress also the cultural value of English to the engineer.

Concrete Designers' Manual—Tables and Diagrams for the Design of Reinforced Concrete Structures. New Second Edition. Geo. A. Hool, Professor of Structural Engineering, Univ. Wisconsin. Chas. S. Whitney, Structural Engineer. 327 pp., flexible, 96 diagrams, 90 tables. $4.00.

These tables and diagrams make possible the rapid designing of reinforced concrete structures. The text is limited to explanations of the tables and diagrams. Where necessary, specific examples of how to use the diagrams are given.

ENGINEERS & ENGINEERING

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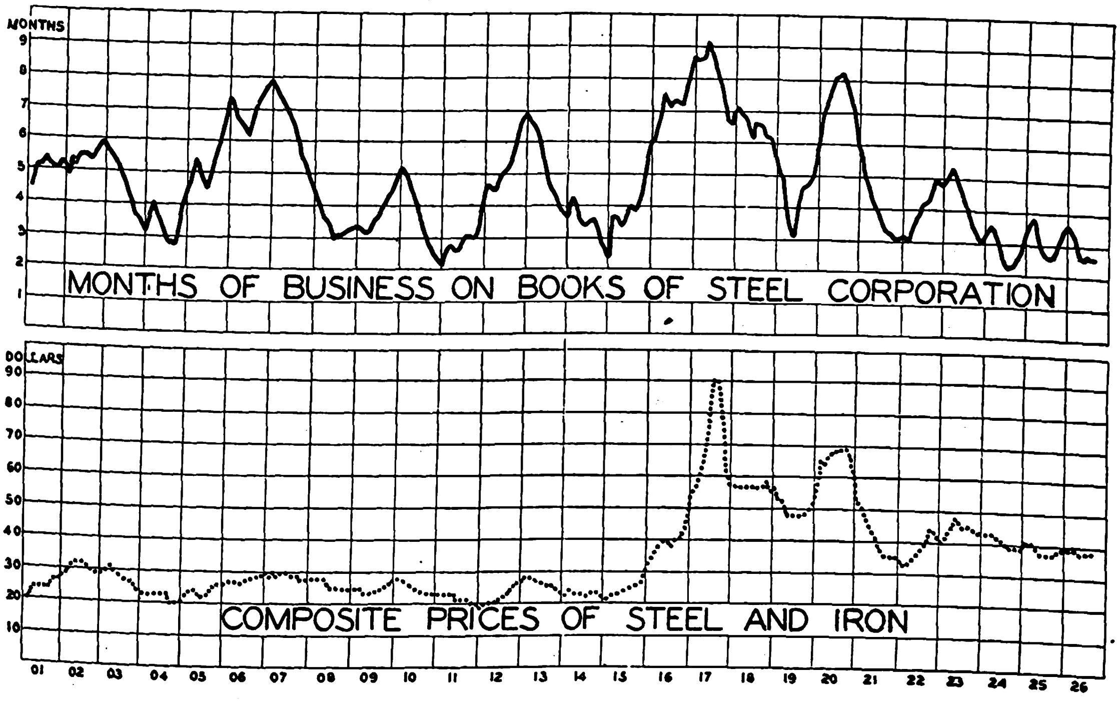
Business and Banking

ONE of two outstanding features of the month of October was a sharp decline in the value of corporate capital as represented by shares of stocks bought and sold on the stock exchanges of the country. Out of a clear sky and on the second day of the month, Saturday, a short day, a recession began which, with some slight recoveries in the meantime, lasted until the last week. It was what is classed as a professional drive, and, with the possible exception of the cotton situation, which is quite speculative, exerted no particular influence on industrial activities. Ordinarily a raid on prices, such as occurred, brings with it some curtailment of production and occasionally cancellation of orders; but in this instance, either because the soundness of business is too well established or the drive too shortlived, it was, up to the close of the month without noticeable outside effect.

In its Business Bulletin, published the middle of the month, the Cleveland Trust Company features the business done and prices received by the United States Steel Corporation, illustrating by the use of graphs which are reproduced here. It brings out a condition that has been one of the features of many lines of business all year, namely, hand-to-mouth buying, which, on looking backward may easily be interpreted as shrewdness on the part of business and the avoidance of loss on inventory as a result of declining prices. In explanation of its graph, which varies from the usual, The Cleveland Trust Company says:

"Our best and most important series of data relating to forward buying is the monthly reporting by the United States Steel Corporation of the volume of unfilled orders on its books. During the past two



Courtesy of the Cleveland Trust Co.

years the volume of these orders has been about as low as it used to be in periods of industrial depression, and this has been so in spite of the fact that building construction, automobile production and general manufacturing have been at record breaking levels."

"In the diagram the upper line shows for each month during the past 26 years the volume of unfilled orders of the Steel Corporation. *It does not show these data in thousands of tons, but rather in terms of the number of months that all the plants of the Corporation would have had to produce at 100 per cent of capacity in order to fill all the orders on hand.* In such boom years as 1906, 1917 and 1920 the unfilled orders were so large that the plants working at full capacity would have required eight or nine months to fill them. This year, and during depressions, the volume has fallen to the equivalent of capacity output for only about two and a half months."

"In the lower section of the diagram is a line showing the average composite prices of iron and steel products each month over the same years. A study of the fluctuations of the two lines will show that they tend to move up and down together, with the unfilled orders usually moving a little earlier than the prices. To put this another way, the fact is that users of steel tend to increase their forward orders while the prices of steel products are advancing, and to reduce them while prices are falling. The price movements seem to have a little more momentum than the orders, so that the changing volume of orders constitutes one means of forecasting price trends and changes."

* * *

The other feature was reflected in international banking for the Kingdom of Belgium. In part for the purpose of re-establishing the gold standard, the stabilization of its currency and the balancing of its budget, Belgium created a loan of $100,000,000 (equivalent) one-half of which was taken by England, Holland, Switzerland and Sweden, and the other half came to the United States. The favorable reception given by American investors to the loan stimulated quotations for almost all continental European bonds, and at the close of the month many, and especially those of the French Republic, were actively selling at their highest prices for the year. Approximately a week before the offering of this loan what has become known as The London Manifesto had been promulgated. This was an economic declaration signed by leading bankers and business men of sixteen countries urging the removal of tariff barriers which at present hamper the recovery of the world, and especially that of former belligerent countries of Europe, from the economic loss and disorder wrought by the war.

These events, probably plus the fact that conditions at home are about as they have been during recent months, had the effect of creating larger interest on the part of American economists in the affairs of other countries, and especially the international selling pool that was formed by the iron and steel producers of Germany, France, Belgium and Luxemburg. In summing up the economic and political significance of this undertaking the Guaranty Trust Company of New York expressed its beliefs in the following words:

"From the economic point of view the most important feature of the trust is its provision for cooperation between the ore mines of Lorraine and the coke industry of the Ruhr. The necessity for some form of coordinated action in this direction has long been recognized by those familiar with the position of the steel industry on the Continent. On the political side, the community of interests established by the combination is expected to result in closer sympathy between France and Germany as well as between the other parties to the agreement."

"It is uncertain to what extent the trust contemplates, or may eventually undertake, organized competition in neutral markets against producers in other countries. For the time being the main purpose appears to be to exclude outside interests, so far as is practicable, from European steel markets; to restrict competition among its own members; and thus to stabilize prices at a level which will assure reasonable profits to producers. In so far as the last-named purpose is accomplished, the operation of the agreement will work to the advantage of American steel manufacturers, as well as those of other countries—not only by stabilizing and perhaps advancing the price of steel, but also by reducing the danger of sharp price competition in American and foreign markets."

* * *

Conditions more local to the Philadelphia district are reported by the Federal Reserve Bank, in part as follows:

"The early fall has witnessed a general expansion of business activity. Much of the recent increase, it is true, is of a seasonal nature, but in most lines of business the current volume is well ahead of that of last year and of 1924. Manufacturing activity in the district has increased since early summer. The current rate of operations is equal to the high level of February and March of this year, and is as great as at any time in the past two years. Building operations in the district also continue very active and the anthracite mines are working close to capacity. Business payments, as reflected by debits in the leading cities of the district, have shown seasonal expansion since August and continue, as in practically every month of the present year, to exceed the volume in the corresponding month of previous years."

"Distribution of goods in the district continues at an active rate. Freight car loadings in the Allegheny district have increased seasonally in September and October and are well above the level of any previous fall. Wholesale business in drygoods, electrical supplies and jewelry was smaller than in September, 1925, but all other lines of wholesale and retail trade showed large gains in September and current sales continue above those of last year."

"Retail sales not only have been larger, but stocks of goods are smaller and turnover more rapid this fall than in 1925."

Business Indicators Philadelphia Federal Reserve District	September, 1926	Latest figures compared with Previous month %	Latest figures compared with Year ago %
Retail trade — estimated net sales (142 stores)..	$20,811,000	+24.1	+ 4.6
Department stores (65)	$16,707,000	+26.6	+ 3.8
Apparel stores (36)...	$2,747,000	+16.3	+10.6
Shoe stores (24)......	$582,000	+11.5	+ 9.8
Credit stores (17).....	$778,000	— 7.4	— 2.0
Wholesale trade — net sales (140 firms)......	$10,602,268	+15.1	+ 4.2
Boots and shoes (10 firms)	$483,495	+20.4	+17.2
Drugs (14 firms).....	$1,649,399	+ 4.8	+ 2.1
Dry goods (15 firms)..	$1,007,971	+33.6	— 4.0
Electrical supplies (6 firms)	$499,105	+11.0	— 4.2
Groceries (48 firms)...	$3,876,692	+17.8	+ 9.2
Hardware (26 firms)..	$1,923,046	+10.0	+ 1.3
Jewelry (11 firms)....	$521,619	+19.5	— 1.5
Paper (10 firms)......	$640,941	+16.0	+ 6.7
Production:			
*Shoes (90 factories)..prs.	1,254,139	— 2.1	.....
Pig iron ....tons	308,388	— 0.8	+17.1
*Hosiery (108 mills)..doz. prs.	1,036,968	+ 3.7	.....
Iron castings (33 foundries) ....tons	5,294	— 2.3	+ 7.7
Steel castings (11 foundries) ....tons	7,784	+15.9	+56.8
Cement ....bbls.	3,936,000	+ 0.9	+ 6.8
Anthracite ....tons	8,444,000	+ 2.7	Strike
Bituminous coal—Pa..tons	12,503,000	+ 5.6	— 5.8
*Wool consumption (77 mills) ....lbs.	8,599,795	+22.2	.....
Active cotton spindle hours (Pa. and N. J.)	83,868,241	+32.8	—30.1
Electric power—12 systems ....KWH	372,252,000	+ 1.6	+19.0
Distribution:			
Freight carloadings (Allegheny district—weekly average).....	229.771	+ 4.0	+10.6
Tonnage of vessels (Port of Phila.).....tons	3,587,234	— 2.3	+17.3
Exports of wheat (from Port of Philadelphia) bus.	839,000	—22.8	—26.2
Exports of flour (from Port of Philadelphia) lbs.	5,242,926	+82.6	+90.7
Imports of crude oil (into Port of Phila.). gals.	1,721,832	—65.2	—84.6
Financial:			
Loans, discounts and investments of member banks (weekly average)	$1,161,000,000	+ 2.0	+ 6.8
Bills discounted held by F. R. B. of Phila. (daily average)......	$6,224,000	+ 0.8	— 5.8
Acceptances executed (9 banks for month ended Oct. 10)......	$3,458,000	+21.7	—22.0
Commercial paper sales (6 dealers)..........	$5,577,400	+36.5	+ 1.3
Savings deposits (99 banks)	$600,725,000	+ 0.03	+ 5.4
General:			
Debits (18 cities).....	$2,333,284,000	+ 7.9	+ 3.4
Commercial failures — number	70	+59.1	+ 9.4
Commercial failures — liabilities	$1,277,514	—21.6	+37.6
Building permits (16 cities)	$14,534,489	— 7.0	— 3.4
Building contracts awarded (Philadelphia district).........	$39,188,640	— 1.5	+25.5
Employm't—882 plants in Pennsylvania:			
Number of wage earners	302.761	+ 1.9	+ 5.6
Total wages.........	$7,716,087	+ 2.2	+ 7.2
Average weekly earnings	$25.49	+ 0.3	+ 6.3
Sales of life insurance (Pa., N. J. and Del.).	$65,861,000	— 8.9	— 2.8

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*Bureau of Census preliminary figures.

FREDERICK CARLES.

Items of Interest

Largest Diesel-Electric Tugs for Panama Canal

Evidence of the growing sentiment in favor of Diesel-electric ship propulsion is found in the fact that the Panama Canal Commission will add, to its present fleet of steam engine driven tugs, two tugboats propelled by the Diesel-electric type of drive. In addition to being the first of this type for operation in the Panama Canal, these will be the largest and most powerful Diesel-electric tugs in the world.

One tug will operate under the supervision of the marine division of the canal on the Pacific Coast, towing large vessels into and out of the entrance of the canal, and the other will be operated by the dredging division for dredging operations in various parts of the Canal. Each boat will have an overall length of 150 feet.

The power plant of each tug will consist of two 6-cylinder, 480-horsepower Diesel engines, each direct connected to a 330-kilowatt, 257-r.p.m. main generator and a direct-connected auxiliary generator of 50-kilowatt rating. The auxiliary generator will supply power for running auxiliaries, lighting the boat, etc., and will also act as an exciter for the main generator and the propulsion motor.

The propulsion motor will be a 750-horsepower, single-armature, 150-r.p.m., shunt-wound, direct-current motor governed by the variable-voltage method and controlled from the pilot-house. Among the electrically-operated auxiliaries will be a hydro-electric steering gear, an air compressor and a single stage centrifugal fire pump. There will also be a motor-driven fuel oil transfer pump and two other motor-driven rotary pumps having a capacity of 250 gallons per minute each.

2,100,000-Volt High Tension Laboratory

The highest voltage yet obtained by man at commercial frequency—2,100,000 volts—was demonstrated in the new laboratory of Stanford University, California, on Friday, September 17, before an assemblage of eminent men of science, education, and the press, when a ribbon of flame, more than 20 feet long, leaped between two points high in the air, above six giant transformers.

With this new equipment, experiments will be carried on under the direction of Professor Harris J. Ryan, to determine the necessary facts for engineers to design equipment to handle the high voltages, which will be needed in the near future, when electrical power in the far west will have to be carried over long distances, from its sources in the waters of the mountains to the markets in cities and valleys hundreds of miles away. The laboratory will also be used, in working out practical problems, by scientists and engineers of the electrical industry with whom Dr. Ryan has co-operated for a number of years. The laboratory has been erected by Stanford University, with the aid of a number of the large electrical concerns of the Pacific Coast and the nation, which initiated the enterprise, in recognition of the contributions of Dr. Ryan to electrical science and industry, and to insure his continuing his research work which has outgrown the capacity of the high voltage laboratory building which the university erected in 1913.

The new laboratory is an immense structure, with a steel framework, covered with asbestos. The main building is 173 feet long, 60 feet wide, and 65 feet high. It has an interior height of 50 feet in the clear to the roof trusses, with no supporting columns. For some experiments the building can be made light-proof and for other uses practically one whole side can be rolled away. The reason for the movable side, and for the great space within the building, lies in the fact that safety for life and equipment requires that there be a full 20-foot clearance everywhere about the main electrodes.

A much smaller building, of concrete, has been built adjacent to the north side of the main building to contain the requisite power plant and voltage control facilities, offices, instrument, photographic dark and seminar rooms.

The six transformers are of special design, the work of Allen B. Hendricks. Each unit is rated at 350,000 volts high tension, 2,300 volts low tension, and weighs 22 tons. They have been so designed and constructed that they may be used in every manner of connection for the whole range of voltage, single phase or three phase, up to 2,100,000 volts single-phase, 1,200,000 volts three-phase, and lesser voltages.

Three transformers are connected in series, by the so-called chain connection, in order to obtain 1,050,000 volts between the high voltage terminal of the third transformer and ground. When six transformers are connected in series with the mid-point grounded, there will be obtained 2,100,000 volts between outside terminals. For three-phase operation the six transformers are connected in three groups, each consisting of two transformers in series. The three groups are connected in Y and the neutral grounded. This gives 700,000 volts between each terminal and neutral, and 1,200,000 volts three-phase between terminals. At full rated load, 350 KVA. is required for each transformer, or 2,100 KVA. when all six transformers are in use. Each transformer is supplied with a voltmeter coil.

Two motor generator sets are provided, each consisting of a 500 KVA. 0.9 power factor three-phase 60-cycle 2,300-volt synchronous motor, coupled to a 1,050 KVA. single-phase 60-cycle 0.3 to zero power factor loading, 2300/1150 volt sine wave a.c. generator. This generator also is capable of delivering about 1,500 KVA. three-phase at rated voltage.

Two direct-connected exciters are furnished with each set. The smaller or ten-kilowatt exciter furnishes excitation for its own field, for the field of the motor and for the field of the larger exciter. The larger or 33 kilowatt exciter furnishes excitation to the field of the generator. Both exciters are especially designed to give stable operation down to very low excitation. This feature, coupled with the fact that the generator exciter is itself separately excited and, the further feature of series-multiple connection on the generator, allows the set to be operated very satisfactorily down to almost any voltage desired.

For measuring the high tension voltage there is provided a spark-gap consisting of 1,000 mm. spheres.

Stanford University has appropriated, from its widespread campus lands, a strip 100 yards wide and a mile and a quarter long, for an experimental high voltage transmission line, and has reserved additional land to make possible a right of way seven miles long when it is needed. All told, the university is devoting about 200 acres of its land to the laboratory.

Such studies and tests as those which Professor Ryan and his assistants will carry on, in the new laboratory, are vitally essential to the growth and continued prosperity of the Far West.

A Successful Business

An undeniably successful venture in public service is the annual sale of Christmas seals, the receipts from which are used in fighting tuberculosis. Within twenty years this undertaking, which is the chief support of the national, state and local tuberculosis associations of the United States, has developed from a $3,000 business to one whose gross receipts in 1925 were approximately $4,900,000. From a tiny hospital for tuberculous patients in Delaware which was financed by the first $3,000 in 1907, it has become the means for creating a network of sanatoria, hospitals, open air schools, clinics, and other public health activities that protect the American people against what was once known as the Great White Plague.

All but five per cent of seal sale money is spent in the communities where it is raised. The five per cent goes to the national body which acts as a clearing house for information, supplies, leadership, research and expert service for its affiliated organizations, and for the other allied institutions and agencies.

DEPARTMENT OF COMMERCE
Washington

Experiment in Welding Steel

A new welding process which, it is announced, promises to give the construction industry more rapid fabrication at a lower cost and a relief from the noise of riveting, has been tested with satisfactory results at the Bureau of Standards of the Department of Commerce. In announcing the test, Bureau scientists referred to it as "another step in making possible noiseless steel construction by welding instead of riveting."

Properties and Manufacture of Concrete Building Units Described in New Publication of Bureau of Standards

While concrete units have long been used in building construction it is only within the past few years that the manufacture of concrete brick, block, and tile has attained a rapid growth. This growth has been brought about largely by the heavy demand for building materials and the efforts of interested associations in bringing to the attention of the public the desirable features of concrete units. Numerous inquiries are received from people who are interested in learning more of the properties of concrete units and the details of the manufacturing methods.

The Bureau of Standards has prepared a circular covering the essential features of concrete, brick, block and building tile, and giving some general information about the manufacture.

Copies of this circular can be obtained by writing to the Superintendent of Documents, Government Printing Office, Washington, D. C., for Circular No. 304, the Bureau of Standards. The price is 20c.

The more important properties of concrete units are discussed and some of the advantages of their use in masonry building construction are set forth. Concrete block, tile, and brick have been defined and the recommendations for the standardization of sizes of the several types of units to avoid waste are given. The recommended standard sizes adopted are given as well as the large number of sizes in present use. This comparison shows that by maintaining definite standards of size for the units a large saving will result in the outlay for machinery, molds, and pallets, as well as the stock to be carried in yards.

Various materials widely used in the manufacture of concrete products are described in detail. The questions of proper size and quality of both coarse and fine aggregates are discussed and the use of admixtures, facing materials, and coloring processes are outlined. The need of careful proportioning, the proper time of mixing, the methods of molding, and the several means of curing are discussed at some length. The requirements for concrete units are dealt with from the structural, architectural and fire resistant viewpoints. The methods for conducting tests of concrete products and the proper interpretation of data from test reports are outlined.

Factors affecting the financing of a concrete products plant are considered from an economic standpoint and suggestions are made to prospective investors to investigate fully all local conditions which may affect the life and successful operation of a plant.

The circular proper is followed by a bibliography of books, technical papers, and periodicals dealing with various phases of the manufacture of these units which will be of particular interest to those contemplating entering this line of work. Several specifications are also given from the standards of the American Society for Testing Materials governing the quality of aggregates and the method of testing, together with the American Concrete Institute specifications for concrete block, tile and brick.

Tests of the Fatigue Strength of Cast Steel

The widespread and growing use of steel castings for stress-carrying members in machines and structures, and especially their use in railway rolling stock, has called attention to the lack of available data on the fatigue strength of steel castings, that is, the ability of steel castings to resist repeated stress without being fractured. Realizing the need of such data the American Steel Foundries entered in a cooperative arrangement with the Engineering Experiment Station of the University of Illinois for making a series of fatigue tests on cast steels of two different chemical compositions. The tests were carried out in the laboratories for the Investigation of the Fatigue of Metals, which has been in progress since 1919. Although the information secured in the first series of tests is somewhat limited, yet it is believed that the lack of data on the strength of cast steel justifies the publication of these results. Bulletin No. 156, price 10c.

An Investigation of the Mechanism of Explosive Reactions

The numerous changes in the composition of liquid fuels for internal combustion engines and the tendency towards the employment of higher compression ratios, which frequently result in "fuel knock," have indicated the desirability of a more detailed and complete knowledge of the actual mechanism of explosive reactions.

A great amount of experiment work has been done on this problem, but there are so many phases of the general subject that it is difficult to consider more than one or two divisions of the problem in one investigation.

The experiments reported are a continuation of the general investigation of the explosion of gaseous and liquid fuels which has been conducted in the Engineering Experiment Station of the University of Illinois. Bulletin No. 157, price 35c.

A National Policy in Development of Water Resources

Digest of an Address*
By HON. HERBERT HOOVER,
Secretary of Commerce

THE great vision which Secretary Hoover gave in this address is divided primarily into two parts, first, that water is today our greatest undeveloped resource, which has tremendous possibilities in enhancing the development of this country, if it is used to best advantage along a carefully studied predetermined plan, and, second, that the time has come to reorganize the Public works functions of the Federal Government for this development, so that the States and all other interested parties may have the best guidance in the development of the plan and its execution.

The cream has already been taken off in the development of the most lucrative projects, leaving for the most part only the major engineering jobs, and the opportunity of great national design. The progress of science and engineering has revolutionized the possibilities of our water resources but, those possibilities have hardly been scratched in the plan so far developed. This negligence presents an appalling figure in what is otherwise a very efficient nation.

Each of the great drainage systems of the country should be studied separately and a program laid out that will permit of vigorous development over a term of years, so that we can anticipate the need of the 40,000,000 additional people who will live in this country twenty-five years hence. Mr. Hoover referred in detail to his opinion concerning the development of the following major projects: 1. Colorado River; 2. Columbia River Basin; 3. The Mississippi System; 4. The Great Lakes System; 5. The Tennessee and Cumberland Rivers; 6. The Arkansas River; 7. The Rio Grande; 8. The Hudson River; 9. The Intercostal Canal; and, 10. The Interior Valley of California.

Every section of the country should be intensely interested in each development, because it will contribute materially to the effective progress of our whole country, thus assisting every branch of industry and improving our whole economic condition. Fear of the farmer, that more land will cause overproduction of agricultural products, is dispelled by an analysis of the rapidly mounting needs of the country which will be actually upon us before the development can be completed. The anxiety of our railroads over competing water developments is dispelled, by pointing to the congestion already existing on our railway systems and terminals, and the fact that we must during the next quarter of a century, provide for the expansion of facilities to handle at least double what we are moving today. Water systems would simply be made an adjunct to rail and motor transport.

Pointing to the problems of interstate friction and litigation which have arisen under present inadequate plans, and to the great problems of finance and ownership of the projects, Mr. Hoover warns that the primary requirement to a national advance in the solution of these problems is better organization, both for determination of plans and for their execution. The Federal Government is now spending, on isolated work under the Rivers and Harbors appropriation and under the Reclamation Act, sums aggregating approximately $65,000,000 a year. This should be enlarged and support from the states sought. The Federal Government should begin with an increase of $25,000,000 annually, and raise it to $100,000,000 which, together with the collateral expenditure of States, local communities and the hydro-electric companies, will permit the completion of many of our most pressing projects in the next ten years. All such expenditures are capital outlay which every soundly run business makes when it looks to increasing its revenue. The nation can reduce its tax rate by increasing its wealth in reproductive work of this nature.

Secretary Hoover states that with an improved organization, recognized by him as a prime requirement, our first need is complete engineering studies of every drainage system, in order that we may have the basic facts upon which to base engineering plans. We already have such information but, incomplete in every case. The second need is organization to determine procedure and to coordinate interests. This can be accomplished by the development of suitable commissions on which all interests are represented.

"Our third need is better organization of our agencies for construction and administration, with a view to reducing conflicting agencies in the Federal Government, to building up a center point for real and constructive national policies, for administration in engineering and construction, and great economy in expenditure. Secretary Work and I have many times recommended that all of our different federal activities in public works be concentrated in a Public Works Division of the Interior Department, with our able Army engineers assigned to that section in peace time. All this to be under direction of an Assistant Secretary of Public Works.

"A plan such as I have outlined follows the essential principles of good administration and sound public action. It separates the advisory and the judiciary questions from administrative and executive questions. In the former we need the value of many minds in order to secure the best judgment and widespread co-ordination and co-operation. In execution we need single-headed responsibility. Our national development will be advanced by many years and executed at much less cost if such organization can be brought about."

Editor's Note: In this address, complete copies of which are available in printed form, Secretary Hoover has again blazed the way for the public works organization.

The public generally, and engineers especially, should do everything possible to make this great public service effort successful at the earliest date. ENGINEERS AND ENGINEERING will be glad to furnish, upon request, full information and reports of progress.

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*Delivered at Seattle, Washington, August 21, 1926.

Observations on the Transit Situation in Some European Capitals

By S. M. SWAAB

Consulting Engineer to the Mayor of the City of
Philadelphia, Past President, Engineers
Club of Philadelphia

ASIDE from the water supply and sewerage and general sanitation, which subjects may be said to determine the health of a city, there is no subject involving engineering more important in any city of a population of five hundred thousand, (except possibly the location of the city itself), than is the subject of transportation. I take it that a city that will accommodate so many people has arrived at that stage of its development which forbids further growth, unless transit facilities are seriously considered.

Many of the cities of the old world experienced congestion long before the automobile was thought of. In some of these cities the streets are particularly narrow and some of them are quite crooked and most of them badly paved. They were laid out without any reference to vehicular traffic whatever.

With the increase in population and in the number of motor vehicles, the streets in all of the older cities have become congested to such an extent that it has become a serious question how to regulate the traffic so that at its peak it may be best provided for.

The congestion of traffic to which we have reference came into being with the advent of the automobile. It might possibly have been averted by building wider streets at the outset, regardless of economy. At this date, however, this would be entirely a matter of academic discussion. There is no doubt that for several decades the problem we are considering today has been in the public eye.

The traffic problem is common to all of the great cities of Europe and America alike. The most noticeable thing in Europe is that far fewer private motor cars exist there than in this country but in the cities of London and Paris, this deficiency is more than made up by motor busses and taxis. In some of the European cities the horse drawn vehicle is still very much in evidence and Holland has been called the land of a million bicycles.

The big cities in Europe are struggling with much the same situation as we in this country. The authorities in London and Paris realize the seriousness of the situation and particularly in these cities have the streets almost reached the point of saturation. It is barely possible to admit of further material increase in motor traffic unless strenuous means of regulating it are adopted.

The capacity of a street for vehicular traffic is dependent on several things, among which are the distance apart of intersecting streets at grade, the paving, the grades, the character of the neighborhood, whether business, manufacturing or residence—but the width between the curb determines the number of lines of vehicles.

The problem in each of the European cities is different and cannot readily be compared with that in our city. This is due primarily to differences in the City Plan. There are many other contributing factors of which the density of population in the various sections of the city and the relation of the various centres of population and of industry are two of the more important.

In the European cities, the surface traffic is handled by the police better than it is usually handled in this country, by reason of the fact that the average European has more respect for police regulations than have our citizens. When I say this, of course, I mean that up to a certain point they probably have more respect for police regulations than we have, as beyond this they do not hesitate to show their open defiance if it suits their pleasure or convenience. This may best be illustrated in this way. In the City of Paris the police made a regulation forbidding more than 40 kilometers or say 25 miles per hour, as the maximum speed on the street surface. At the Prefecture of Police, they say that they found it impossible to enforce it, so that rather than allow the law to be openly flouted, or disregarded, they withdrew the regulation. At present any speed that is physically possible is permissible, as long as no accidents result and from the information I have secured they are comparatively few.

Paris, as poor as it is said to be, has been engaged in building an extension of the Boulevard Hausmann and in this process has cut a swath through the buildings, some of which, judging from appearances must have cost considerable money. In widening the Strand in the City of London, they are not adding sufficient to its width, in my judgment, to render it adequate for a long time.

Arcading in the City of Paris was a part of a general rebuilding scheme and was done entirely for architectural effect. No thought was given to providing more street width than existed between the building fronts, as in fact none was needed at that time. The arcades, in the City of Paris, were built by direction of Napoleon the First, through buildings which were erected for public purposes.

In the City of Paris, several different kinds of transportation are offered. The Metropolitan and the so-called Nord-Sud (underground) reaches to every part of the City—surface cars are operated in certain parts of the City, and busses practically reach every part of the city and surrounding country. There are upwards of 15,000 taxi cabs, in addition to certain motor cars which are used as taxis and are much patronized in sight seeing by Americans. Five thousand taxi cabs were used in transporting the garrison of the City of Paris to the Marne in the late War. I have never learned just why they employed the taxi unless it was that the busses were needed in Paris to take care of the regular business. The taxi is of course a very uneconomical transportation facility as compared with the bus, based on the number of persons carried and the cost of operation.

These cabs are used practically by all of the transients and of course by some of the natives as well. It is recognized by the authorities that there are not sufficient cabs at present in Paris and this is painfully in evidence whenever it rains. What is going to happen when additional cabs are placed on the street is something on which the Paris police do not even wish to risk an opinion.

No attempt has been made at synchronized Traffic Control in the City of Paris, nor in fact anywhere in Europe, as practiced in this or in New York City, but I was advised that preparations are being made to try it out on the Champs-Elysees. The streets in the City of Paris, particularly the Grand Boulevards, are so much wider than those in this city that no direct comparison can possibly be made.

At the principal crossings, such as the Ronds-Points des Champs Elysees, the Opera and the Concorde, where traffic is very thick, it is controlled directly by a mounted policeman using a whistle to signal a policeman stationed on the street corner, to either stop or let traffic pass.

I have, on several occasions stood at each of these points and observed the methods in vogue. At the Arc de Triomphe, from which radiate several of the Boulevards, any lack of knowledge of the rules of the road on the part of a driver would end disastrously, and it should be said for the Paris chauffeurs that they know the rules very well.

I have also observed this system in operation at the streets intersecting in front of the Opera House, undoubtedly the most congested street intersection in Paris, and it seems to work satisfactorily. From personal observation this is the most dangerous intersection for pedestrians that I have seen anywhere, either in Europe or in this country. This has been called the most crowded street intersection in the world.

Each street corner where traffic is controlled is independent of all the other corners, that is, along one long street the traffic is not moving and stopping as a single unit control.

At the majority of the principal street crossings along the main boulevards, to stop the traffic a red light, conveniently situated is flashed with the word "Halte" written across the face. A policeman is always standing at the foot of this light to see that it is properly obeyed. At the same time as the policeman puts the light out to let the traffic go on, a bell rings for a period of about five seconds.

On one-way streets, the entrance to same in the forbidden direction is protected in some cases by a blinking red light which has across the face "Sens Interdit." In other cases, merely a temporary red painted sign with the same wording.

On the Champs-Elysees, pedestrians are not supposed to cross except where there are safety islands and where there is a sign, of which there are a good many, which read **"Traversee pour les Pietons."**

Regarding parking on small streets, there is a rule now in effect whereby on even days of the month, that is 2nd, 4th, 6th, etc., the cars are only allowed to park on that side of the street where the houses have even numbers, and on the odd days of the month on the side where are the odd numbers.

On certain streets horse drawn vehicles are allowed only between certain hours and when the traffic is light.

A school is maintained for the instruction of traffic policemen. Men showing a natural propensity for this character of service and men of assured good judgment, are thoroughly instructed in all of its features, by the men who have had actual experience on the street and also by those who formulate the rules. Only men, who by previous employment in other branches of the service have shown particularly good judgment, are employed in the traffic service.

I am advised that there are, at this date one thousand men employed exclusively in this service. The total number of men employed on the police force in the City of Paris is given as nine thousand.

Statistical Data

In the first six months of 1914, eight thousand owners of new cars applied for circulation permits in Paris. In the ten year period between July, 1914, and July, 1924, ninety thousand cars were given permits to circulate in Paris. This is, of course, exclusive of cars which operate without Paris licenses.

In 1923, there were upwards of 119 persons killed by vehicles, or about one to twenty-five thousand population (Paris and environs 3,000,000 pop.), and there were 14,819 persons wounded in street traffic of every character.

The total accidents for the year 1923 were reported as follows:

	Men	Women	Children	Total
By Tramways	10	3	1	14
By Auto-Busses	4	4	2	10
By Automobiles (incl. taxis)	25	27	21	73
By Horse Vehicles	12		8	20
By Bicycles		1	1	2

A total of 14,819 were wounded in street traffic as follows:

	Men	Women	Children	Total
Tramways	1041	610	73	1724
Busses	349	180	24	553
Automobiles	5592	2482	820	8894
Motor Cycles and Side Cars	215	106	31	352
Horse Vehicles	1473	537	199	2209
Bicycles	469	428	190	1087

Since there is no speed limit in Paris the driver of a motor vehicle must always have it under control. He must be able to slow up suddenly or even stop short to avoid accident. In the matter of leaving it to the "Chauffeur's good judgment" entirely, the Prefect has given me the following police figures for 1924 as representing the number and character of the infractions of the traffic rules.

	Private Cars	Taxis
Disregarding signals	251	402
Excessive speed	1,108	741
Neglect to keep to right	2,418	1,026
Bucking traffic	1,419	606
Blocking traffic	326	385
Illicit parking	1,413	1,628
Backing into traffic	199	226
Crowding cars	368	396
Abuse or neglect to use horn	268	155
Improper stealing ahead in traffic	598	439
Diverse embarrassments of traffic	3,319	771
	11,687	6,775

From these figures it is evident that the private cars are by far the greatest offenders against the traffic regulations, being responsible for about two thirds of them.

It is recognized by the habitants and visitors alike that the crossings of a street in the Paris central district is one of the most hazardous things that one may do in Paris, among the many hazardous things that one may do in that city.

In Hamburg and in Brussels, letter boxes are carried on the street cars which pass the post office. This, they claim reduces the number of motor and horse drawn vehicles used in the collection of the mails.

In Amsterdam, Brussels, Berlin, Vienna, Rome and other cities which I visited, the traffic is handled entirely by the policeman at the street corner. It is left to his discretion and I understand he has no fixed set of rules to govern him. In the City of Berlin, an ex-army officer, from appearances at least, is stationed at every street intersection and he possibly commands more respect from the populace than would an ordinary policeman. The traffic, however, is not so plentiful as to require regulation in some of these places and possibly will not be for some time. Brussels, in some sections at least, requires regulation now.

In the City of London, traffic regulations are very much in need and as I have been given to understand, the problem has been studied at great length by the officials having the matter in charge. No effort at synchronized movement has been made, although there is one point in the City of London, where a traffic signal has been set up and an attempt made at directing the traffic on the streets radiating from this point.

At the rush hours, the streets become almost impassable for pedestrians and motor traffic is seriously handicapped. When the street traffic comes to an abrupt halt in London, I have seen busses almost in contact with each other and the streets fairly choked. Ten miles an hour is the maximum speed that can be made.

The streets are particularly narrow and they are trying to work out a plan so as to use them as one way streets entirely, although there are some quite narrow streets which are used today for two way traffic. The traffic is separated by island platforms, somewhat like those which we have on Broad Street, on which are erected the lamps for lighting purposes. The policeman at the corner is entrusted with the handling of the traffic entirely and it should be said, to his credit, that he is a very intelligent policeman at that and generally uses very good judgment. From what I could see and learn, there are comparatively few accidents, although no statistics are available.

In the City of London, where busses are used exclusively in the heart of the city, or at least where the trolley cars are excluded, there is an effort made to keep the busses moving, rather than to come to a decided stand-still. This makes it necessary for passengers to alight while the busses are in motion and this is indulged in by men and women alike. It is a dangerous practice, however, but not many accidents occur, at least so I am informed.

In Philadelphia certain streets have been designated "one-way" streets and synchronized traffic control is employed on certain other streets. Parking is regulated by Ordinance of City Council and in the down town shopping district between certain hours is strictly forbidden. To make this effective a considerable increase in the number of men in traffic service will be required. The Market Street Subway Elevated, the Frankford Elevated Railway and the Broad Street Subway were built to provide transportation which could not be provided on the street surface.

For purposes of comparison with the City of Paris, the number of street accidents and fatalities is presented.

In the year 1923, there were reported by the police in this city, a total of 10,135 street accidents, of which 352 were fatal, and in the year 1924, there were reported 10,279 street accidents of which 306 were fatal. These accidents were reported as involving touring cars, delivery trucks, mail trucks, taxi cabs, motorcycles, bicycles and trolley cars. In each instance the toll collected by the touring cars was greatest as shown by the records.

It will readily be seen that so far as the average number of fatalities is concerned, there were during these two years, about one to six thousand of population as compared with the Paris figures above quoted of one to twenty-five thousand population, and the wounded were one to two thousand population in our city, which is practically the same for the City of Paris. I am at a loss to understand the difference in the figures representing the fatalities. I should have said, without any figures, that the reverse was true. The Parisians, through long contact with the conditions have probably developed a keen sense of the dangerous character of the passage of the crossings and have learned how best to protect themselves against serious accident.

Before the Finance Committee of the United States Senate last year, when the subject of the restoration of the pneumatic tubes in the mail service was under discussion, I had occasion to make a plea for the removal of the trucks which were used in the delivery and collection of the mails, as the police had complained that these were among the worst offenders against the traffic regulations. On that occasion I remarked that it was as much as one's life was worth to cross certain street intersections in our city at certain hours, having particularly in mind Broad Street at Arch Street, Chestnut and Walnut Streets and Market Street at 8th and 12th Streets—but I never had any conception of what this phrase meant until I attempted to cross some of the street intersections in the City of Paris. Considering the tremendous congestion at certain times of the day at some of the crossings, it is almost a miracle that there are not more accidents than are reported by the police.

In this city, the entire police force consists of about 4,200 patrolmen and 580 officers, less than 5,000 all told, of which number 650 men are engaged in the direction of traffic. When the disparity in the sizes of the two cities, under consideration, Paris and Philadelphia, is taken into account, the disadvantage under which we are laboring, as to the number of policemen—not alone in the traffic service but also for the usual protection afforded by the police—is apparent.

My study of the subject has taught me that the motorbus is the vehicle to which we must look for the best present day results and for the future so far as we can now see. Street car operation in the heart of the City must cease. Their day is past and their operation in the larger and older cities must be abandoned. If for no other reason this is so, because the bus is so much more flexible, and, where regular stops on the sidewalk are provided as they are in Europe, I am sure that the further guarantee of a seat for each patron will do more than anything else to curtail the number of private motor cars for single individuals, which is largely responsible for the congestion we are experiencing.

When the bus no longer suffices street car subways will be required to supplement them. These are, of course, very costly and the people are liable to put up with a whole lot of inconvenience before resorting to them. Eventually, however, they will be built.

When the combination of busses and street car subways does not provide adequate service, possibly the second story street may come into vogue. Possibly also the airplane will be utilized, if landing places at regular intervals can be provided and the service can be made practical and economical. This may some day take the place of a sort of super-express subway service and for all reasonably long distances, but to supplement local service, never. This is a perfectly safe prediction.

What we need in all of the older cities is more street width and to provide this by demolishing large and expensive business properties is likely to be a last resort. The most practical way of widening streets with which I am acquainted, particularly if the street is lined both sides with large and expensive buildings used in business, is to remove the surface tracks. This, of course, presupposes that other means of transportation are first provided. The surface cars operating on rails subdivide the roadway into several lines of traffic and an accident on any one of these is more than likely to tie up the traffic on the entire street. This is of daily occurrence in our own city so that we are all acquainted with it. What we want is flexibility and this the bus provides. The bus which wends its way in the traffic following the line of least resistance, has no such shortcomings as the street car operating on rails. Undoubtedly so far as this is concerned we can learn something from Europe.

The direction of traffic in city streets is a problem in which there are so many variables, and varying conditions, that it does not lend itself readily to synchronized control and it has not been a success, by any means, in any place that it has been used. It is my opinion that the method in vogue in European cities where the traffic is directed entirely by men regularly schooled in the subject and of long experience on the street, is superior to anything which we have done in this country.

The Erection of the Suspended Structure of the Delaware River Bridge*

By R. G. CONE, B.S., Assoc. Mem. Am. Soc. C.E.
Resident Engineer, Central Section, Delaware River Bridge Joint Commission.

THE suspended structure of the Delaware River Bridge is that part supported by the main cables. It consists of a main span of 1,750 feet, and two side spans of 716 feet 8 inches. There are two stiffening trusses, hinged at the towers, into which the floor system is framed. The trusses are of the through Warren type with verticals. They are 28 feet deep with panel lengths of 20 feet 6 inches in the main span and 20 feet 8 inches in the side spans.

Erection

In nine months 18,500 tons of steel were erected and 2,183 lineal feet of roadway slab were poured. The first piece of steel was erected on March 3, 1925, and the last section of slab was poured on December 8th of the same year.

The erection was divided into two distinct phases: Hanging the steel on the cables and adjusting the members for riveting. The distribution of labor between these two phases was about 16,000-man days to the first phase and 20,000-man days to the second.

The erection scheme was fundamentally the same as used on other suspension bridges, and was based on the fact that a hanging rope is an ideal support for uniform loads. Following this principle, the dead load of the structure is applied in successive small increments and the erection of any increment is completed before another is begun. For these reasons, the steel was erected in successive trips or passes of the travellers, adding at each pass increments of the dead load. The first pass contained only the necessary material to support the travellers and was the heaviest pass. The weight of this pass was about 7,000 pounds per lineal foot of bridge, which was one and one-half times the weight of the cables and their appurtenances.

Material was delivered to the site in cars on carfloats except that shipped from the yard on trucks for that part of the structure over Delaware Avenue in Philadelphia. In general, the steel for one first pass move was carried on one carfloat. For succeeding passes steel enough for several days' work was carried on the float at one time. As the travellers moved out from the towers with the first pass erection in the main span, the bottom chord assumed a curve concave upward instead of convex, which latter is the finished shape of the chord. Because of this distortion it was impossible to bolt any of the bottom chord splices during the erection of this pass. In fact, it was often difficult to connect the stringers necessary to support the travellers as they moved ahead. This difficulty was due to the heavy concentration of the traveller at this point, and in some cases it was necessary to move the traveller back before the stringers could be bolted and the erection proceed. After the travellers had passed the quarter points of the main span, the bottom chord became convex downward and further erection altered the curve in the direction of the dead-load parabola. However, at no time during the first pass erection did the bottom chord lie in a smooth curve, but showed the profile of the structure as a series of stiff sections two panels long. This is clearly shown in the deflection curve taken at the time of closure.

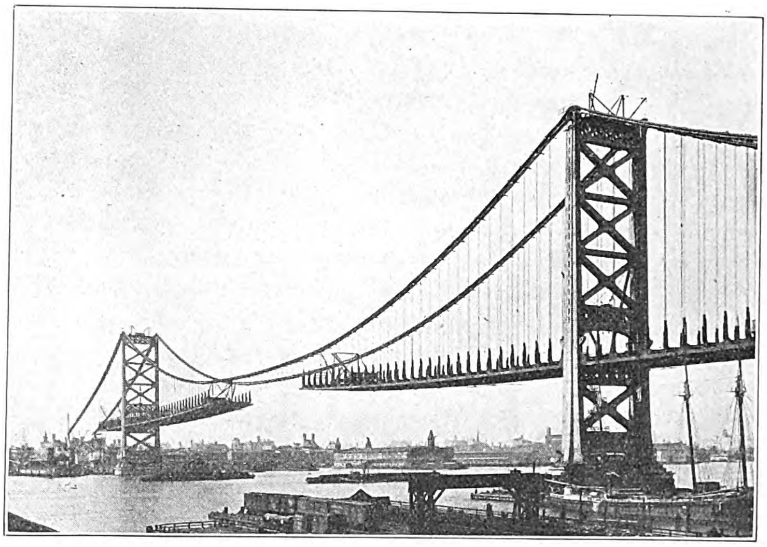

FIG. 1
FIRST PASS ERECTION SHOWING REVERSE CURVE IN BOTTOM CHORD

In detail, the method of erecting the first pass steel was first to attach the verticals to the suspenders; then the bottom chords to the verticals; and then fill in the first pass floor material. The verticals were connected to the suspenders by slipping the suspender sockets under the shelf angles on the member and holding the sockets in place with the slotted shims as shown in Figure 2. The shims were secured by bolts extending through the shelf angles and the shim packs. The pack of shims varied from 2½ to 5 inches to make up the inaccuracies in fabrication of the trusses and in cutting the suspenders. It may be said in this connection that the calculation of suspender length and the attendant operation of cutting was accomplished with great success. The determination of length involved not only extensive calculation, but also sound judgment in the interpretation of laboratory tests in a pioneer field. The modulus of the rope varied because part of it had been used in the footbridges and some of the inelastic stretch had been removed and the determination of these moduli required careful tests and sound interpretation of the results. The results obtained in the finished structure could not have been better had the dead-load conditions been simulated for measurement and cutting. The field operation of measuring and cutting was accomplished with such precision that the 596 ropes are correct in length and no readjustment of shims was necessary after erection.

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*Extracts from a paper presented at a joint meeting of The Franklin Institute and the Philadelphia Section, American Society of Civil Engineers, March 4, 1926.

The procedure of first pass erection was varied in the center of the main span and the top chord and diagonals were added to the other material since it was found impractical to erect the top chord after the other material had been placed on account of the insufficient clearance between the top chord and the cable.

During the return trip of the travellers to the towers, the second pass was erected. It consisted of the diagonals and was completed in two days. Starting out again toward the center, the main-span travellers began the erection of the top chord as the third pass. In the meantime, the side-span travellers moved back from the centres of the side spans where they had been erecting first pass steel and started erecting top chords, diagonals and whatever other material was on hand. This was done because further first pass material had not been delivered and weight was needed in the side spans to balance the main-span erection.

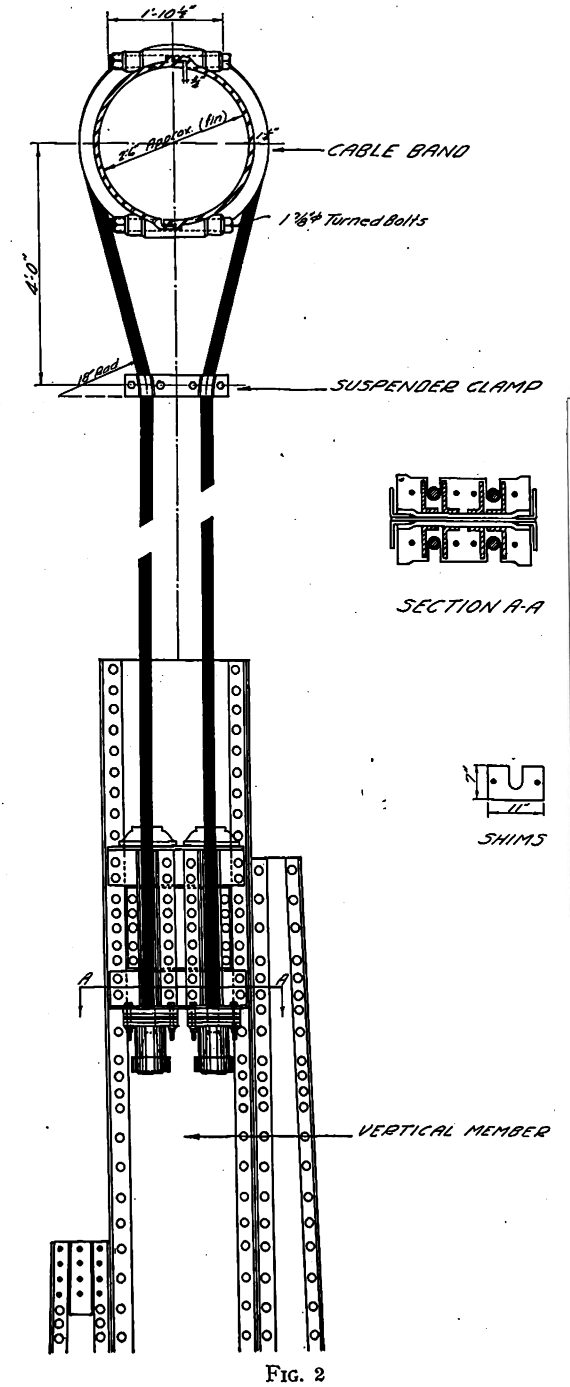


FIG. 2
DETAIL OF SUSPENDER CONNECTION TO VERTICAL, SHOWING SHIMS AND SOCKETS

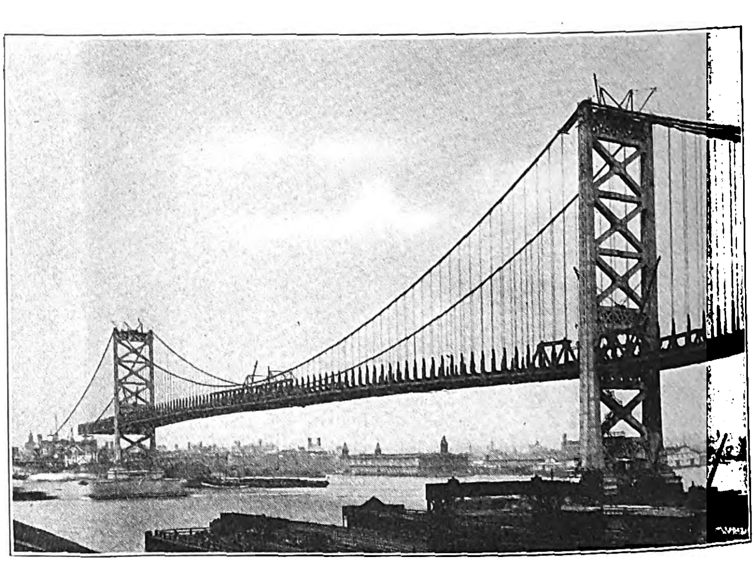


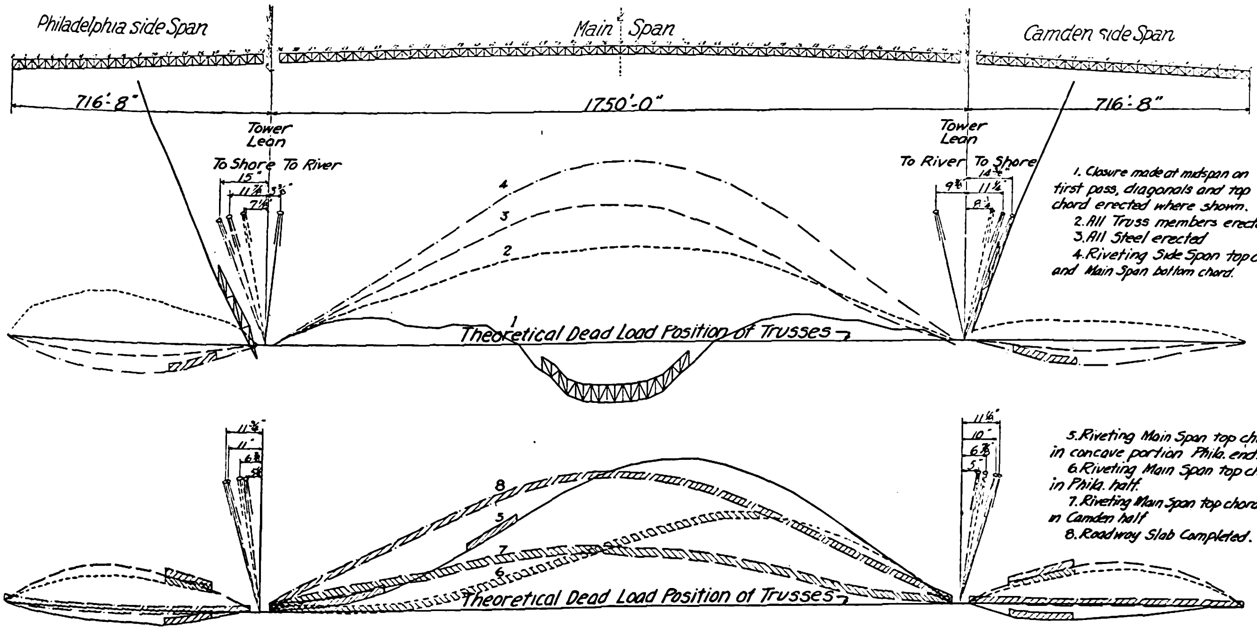
FIG. 3
CONDITIONS AT FIRST PASS CLOSURE

The remaining passes in the main span erected the outside track, sidewalks, and floor material as received. During these passes the diagonals were connected whenever drift pins could be driven in the holes of the connection. In general, this was accomplished with the traveller standing in the vicinity, since its weight was necessary to bring that portion of the span down to its approximate dead-load position. The side-span travellers in the meantime were moving toward the anchorages and completing the erection of the side-span trusses. The diagonals in the side spans were connected by the same method as those in the main span. After the diagonals had been connected, the trusses acted as stiffening trusses for the first time.

Adjusting and Riveting

The second phase of the work was to bring the adjacent members of the trusses to their proper position with relation to one another and rivet them while in this position. Since this operation is peculiar to suspension bridges alone, a review of the attendant conditions and the premises of design is desirable. The trusses in a suspension bridge carry no stress under full dead load at normal temperature. This premise of design fixes the shape of the trusses for fabrication. Accordingly, the main-span trusses were built with their neutral axis forming a parabola with a 15-foot rise. The side-span trusses were laid out with their axes as straight lines on a 3½ per cent grade. Before driving any field rivets in the truss connections, it was necessary that the members to be riveted be in the same relative position as they had been when the trusses were assembled in the shop during reaming. In this position, the milled ends of the chord sections were in bearing and the holes in the other connections were fair. From these conditions it follows that in order to rivet the diagonals, the trusses must be in their "no stress" position while chord splice riveting demanded that the chord be in compression so that the milled ends of the sections be in bearing. In order to establish the "no stress" position of the trusses, the effect of whatever dead load that was not in place must be simulated. To bring the top chords in compression, the effect of live load must be attained in addition. About 6,000 pounds per lineal foot of bridge, or 23 per cent of the entire dead load, is made up of paving, sidewalks, ornamental iron, tracks, conduits, etc. Without this load in place, the cables have less than the full dead-load sag and the trusses are in negative bending. To realize the full dead-load condition over the entire structure at one time would have required about 7,000 tons of surcharge, the cost of which would have been prohibitive. Accordingly, the expedient of partial loadings was adopted and the roadway slab used as surcharge.

This expedient took advantage of the delicate balance of the structure whereby the effect of loading one span without a corresponding load in the others was to bring that span down to or below, its "no stress" condition. Small sections of slab were poured in the side spans before any was poured in the main span. This operation brought the side spans down to one foot below and raised the main span to a point 5½ feet above the "no stress" position. The compression in the top chords of the side spans and in the bottom chords in the main span was sufficient to bring the joints to perfect bearing and they were riveted. After this riveting had been done, the concreting of the main-span slab was begun near the Philadelphia tower. With the addition of this slab, the portion of the trusses in the vicinity assumed a radius of curvature greater than that of the "no stress" curve and the top chords came to bearing for riveting. Slab construction was continued toward the centre of the span, deforming the truss as shown on the deflection curves and keeping the top chord in the position



1. Closure made at midspan on first pass, diagonals and top chord erected where shown.
2. All Truss members erected.
3. All Steel erected
4. Riveting Side Span top chord and Main Span bottom chord.
5. Riveting Main Span top chord in concave portion Phila. end.
6. Riveting Main Span top chord in Phila. half.
7. Riveting Main Span top chord in Camden half
8. Roadway Slab Completed.

DEFLECTIONS DURING CONSTRUCTION

Vertical Scale 0 1 2 3 4 5 FEET

Concrete Slab poured shown thus:- ▨

FIG. 4

for riveting as the work progressed. This operation was successful until the centre of the span was reached. From this point on, the effect of the slab as partial loading was lost, but by pouring the remainder of the span, the centre was brought down to within 18 inches of its "no stress" position. With the truss in this position it was possible to bring the remaining top chord splices to bearing by the use of small surcharges. Two surcharges were used, one a 100-ton load of pig iron on trucks and the other 200 tons of reinforcing steel which was moved by hand when necessary. By manipulating these surcharges to bring portions of the top chord in compression at a time, the remaining splices were riveted. The closing of one splice was aided by heat. In this case one web of the splice had been closed and riveted during the day, but the other web had opened during a temperature drop over night. The open web was heated by oil-burning flame throwers which caused the open web to expand and brought the ends to bearing. Slab construction was suspended two weeks during the manipulation of these surcharges.

During this operation the side spans were 14 inches above their "no stress" position and the bottom chords in compression. The compression was sufficient to force the milled joints to bearing and they were riveted. Of the methods used in closing chord splices, that adopted for one especially recalcitrant top-chord splice in the Camden side span is of special interest. This splice had not closed with the compression that had brought the other splices in the span to bearing. To avoid moving the surcharges to this point the suspenders in the vicinity were released. This made the structure self-supporting and put additional compression in the chord. With this compression it came to bearing and was riveted. With all the chord splices riveted the concreting was resumed and the slab completed.

The diagonals were riveted whenever the truss approached its "no stress" position. The floor system was riveted during all positions of the trusses. This was allowable since the stress expansion joints in the floor prevent its participation in truss stresses. Stress expansion in the floor system is provided every two panels of bridge. The stringers are free to move with respect to the rest of the structure at these points.

The ends of the suspended spans are connected to the towers and anchorages with 16-inch pins. These pin connections carry only live-load reactions. Without the full dead load in place, the suspenders had not received enough stretch to bring the span down so that the pin-holes were matched. It was desirable to drive these pins before the travellers were dismantled. In order to match the pin-holes the travellers were moved to the ends of the spans and the concentration of this equipment was sufficient to stretch the suspenders the required amount and the pins were slipped into position without difficulty.

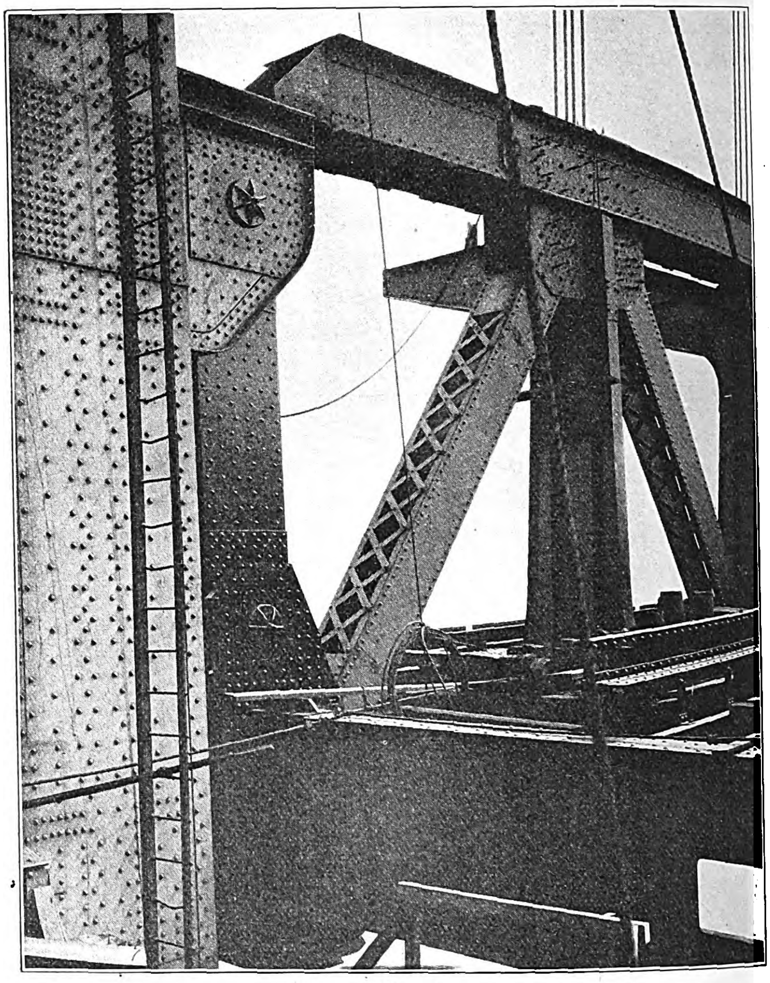


FIG. 5
TRUSS CONNECTION TO TOWERS

Cable Calculations for the Delaware River Bridge[*]

By G. M. RAPP, Jun. M. Am. Soc. C. E.
Assistant Engineer, Delaware River Bridge Joint Commission

THE main cables have received a degree of popular interest and professional attention that has probably not been accorded any other single element of the Delaware River Bridge.

And perhaps no other part of the bridge so well deserves such interest and attention. The two cables compose the main load-carrying members of the bridge, and exert their influence over all parts of the structure. The design of the towers and anchorages, which support and anchor them, depends upon our knowledge of their behavior, while the stiffening trusses, in performing their important functions of limiting distortion and distributing load, follow the cables closely in all movements, and a rational analysis of the former necessitates a full knowledge of their action.

The cables themselves have been so frequently described that I shall only briefly outline their composition, physical qualities and geometry. Two in number, they are each made up of 18,666 parallel steel wires bound tightly together into a compact circular cylinder thirty inches in diameter. Each wire is 0.196 inch in diameter over galvanizing, has a specified minimum ultimate strength of 215,000 lb. per square inch, a specified minimum yield point of 144,000 lb. per square inch, and a coefficient of elasticity of about 27,000,000 lb. per square inch. Each cable is 3,550 feet long from centre to centre of strand-shoes at the anchorages and is held immovably fixed by friction to the towers and anchorage cable bents which support them. The normal sag between towers in the centre span is 200 feet; the normal sag from the chord to the cable curve in the side spans is 37 feet. In round numbers the two cables contain over 25,000 miles of wire, or enough to extend once around the earth's equator, have an ultimate, or proof load combined, of 120,000 tons, and a total elastic stretch from no load to fully loaded condition of about 15 feet.

Let us now view the action of the bridge under loading conditions. With no live load on the structure, and with an assumed normal temperature, the entire dead load is carried by the cables. The trusses remain suspended free in an unstressed condition. The cables hang in their natural curves, parabolas, for this dead load, which is assumed distributed uniformly over each span. In this state the cables, towers and trusses form an elastic system in equilibrium. With the advent of live load or a change in temperature, or both, the cables change their length and shape, the towers bend, and the trusses deflect to accommodate these changes and the entire system takes a new position of equilibrium. The cables and trusses each then take a share of the live load, and the partition of this load depends upon the relative stiffness of the two. The trusses, acting as beams, carry their proportionate amount of the load to the supports at the towers and anchorages, and distribute the remainder of the load to the cables. It is largely this redundancy of load partition, or static indeterminateness, that renders the problem of the suspension bridge difficult for solution.

In studying the effect of loads on the structure it must be borne in mind that no single span is complete by itself; that is, a load on any span is reflected in the other two, or, stated in other words, loads on any span have their counterpart in loads necessary to balance them on the other two spans.

Cable Design

Among the first calculations that must be made are those for determining the maximum pull in the cables. This must be done before either anchorages, towers or trusses can be designed. It may seem a bit peculiar, but it is nevertheless true that the design of the cables themselves, that is, the determination of the required cable area, is probably the most simple problem of the suspension bridge. The largest cable stress requires the bridge to be fully loaded from end to end at the time of lowest temperature, as this is the temperature which gives the smallest sag. The greatest cable stress is found at the towers where the secant of inclination is the largest. This stress divided by the assumed unit stress of 72,000 lb. per square inch gives the required area of cable.

Tower Analysis

In their relation to tower design, or more properly tower analysis, cable calculations play an important rôle. The main towers present the problem of cantilever beams each compelled to deflect definite amounts while acted upon by three forces: The vertical reactions from the cables, the unbalanced horizontal cable tension, and the truss reactions. These forces, together with the displacement of the tower top, all of which are prerequisite to tower design, are dependent upon an analysis of the cable for several critical loading conditions. It is beyond the scope of this paper to treat all these cases of loading, but it will suffice to deal with the general case somewhat in detail. The method of treatment is one of "trial and error" and was developed by Mr. Allston Dana, Assistant Engineer of Design, and extended and elaborated by the writer. It is believed to be rather unique in that it lends itself readily to a physical conception of the problem at every step and is entirely free from complex mathematical quantities. It is even applicable to slide rule analysis with some care and ingenuity. The method is based upon the principle that the summation of all the changes in horizontal span length over the entire bridge from anchorage to anchorage must be equal to zero. The deflection of the cable at the middle of the main span from its normal position is assumed or roughly estimated for the given loading; by neglecting the suspender stretch, which is relatively very small, this also gives us the centre deflection of the truss; by applying the theorem of virtual work to the full truss with uniform load we are able to calculate its stiffness and express this in terms of intensity of load necessary to deflect it one foot at the middle of its span. We are thereby enabled to determine the amount of load carried by the truss system for the assumed deflection; the remainder of the live load on the span plus the whole of the dead load is carried by the cables. It is then a simple matter to figure the increase in cable stress, thence the cable elongation, bringing in temperature effect if necessary, and finally from this new derived cable length and new sag, the new horizontal cable span. So far the main span is treated as a unit by itself. The side spans are slightly more difficult to analyze: Here we have to find, first, the apportionment of live load between cable and truss, then the new cable sag, and finally the horizontal cable span that combined with this sag will give the required new length of cable found as in the case of the main span from stress and temperature changes. By balancing the H's at the tower the sag is expressed in terms of the main-span sag and the intensity of load on the cables in both spans; it may also be written as the sum of the original sag and the new side-span truss deflection, which latter is expressed as a function of the load on the span less the load on the cable. Here again the truss stiffness factor is calculated separately by means of virtual work. In these two equations we solve for two unknowns—the side-span cable sag and the side-span cable load. It only remains to find the horizontal span that is concurrent with this sag and with the length of cable calculated or stress and temperature elongation or shortening.

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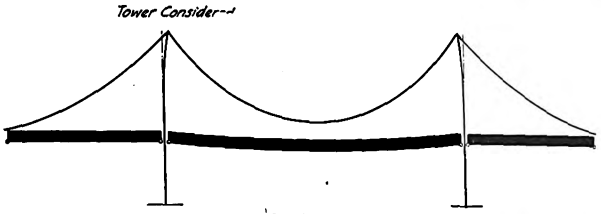
[*] Extracts from a paper presented at a joint meeting of The Franklin Institute and the Philadelphia Section, American Society of Civil Engineers, March 4, 1926.

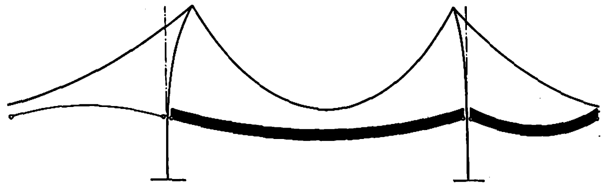
Stiffening Truss Analysis

First and last, the problem of the suspension bridge is an elastic one, and strictly speaking such a bridge might well be classed as a kinetic structure. Deflections are in the order of magnitude of feet instead of inches, as in the ordinary short-span bridges, and it is for this reason that the assumption always made in the latter that the lever arms of the forces do not change under load becomes invalid.



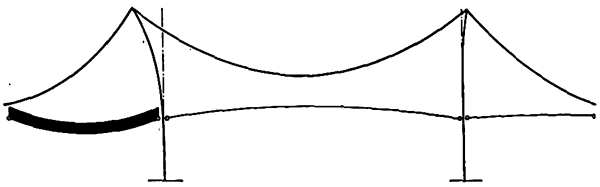
CASE A

Position of Load	Live Load	Dead Load	Temp	V	P	Defl.	Truss Reactions	
							Side Span	Main Span
Over all spans	12,000#/ft	26,000#/ft M.S. 27,000#/ft S.S.	Lowest	34,700,000#			+ 10,000#	+ 6,000#
" " "	6,000#/ft	"	"	29,500,000.#			+ 10,000#	



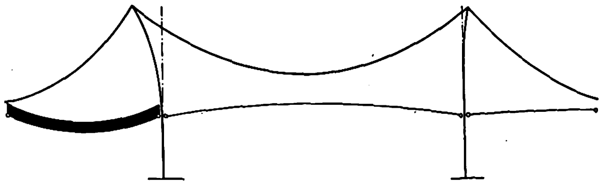
CASE B

Position of Load	Live Load	Dead Load	Temp	V	P	Defl.	Truss Reactions	
							Side Span	Main Span
Main & Far Side Span	12,000#/ft	26,000#/ft M.S. 27,000#/ft S.S.	Highest	33,400,000#	128,000.#	+18"	-1,250,000#	+180,000.#
" " " "	6,000#/ft.	"	"	28,700,000#	80,000#	+ 9"	-640,000#	+110,000#



CASE C

Position of Load	Live Load	Dead Load	Temp.	V	P	Defl.	Truss Reactions	
							Side Span	Main Span
Over Near Side Span	12,000#/ft.	26,000#/ft M.S. 27,000#/ft S.S.	Lowest	24,900,000#	212,000.#	-21"	+1,430,000.#	- 80,000.#
" " " "	6,000#/ft.	"	"	24,500,000#	142,000#	-13"	+ 710,000.#	- 60,000#



CASE D

Position of Load	Live Load	Dead Load	Temp.	V	P	Defl.	Truss Reactions	
							Side Span	Main Span
Over Near Side Span.	12,000#/ft	20,000#/ft M.S. 21,000#/ft S.S.	Lowest	19,200,000.#	317,000#	-26"	+1,550,000.#	- 90,000.#
" " " "	6,000#/ft.	"	"	18,800,000#	223,000#	-17"	+ 760,000.#	- 70,000#

+ Deflections are toward the river.
– " " " " land
+ Reactions are upward
– " " downward.

FIGURE 1

As in the case of the main towers an analysis of the stiffening trusses, that is, a determination of moments, shears, and deflections, depends upon certain cable calculations. The problem becomes one of finding the horizontal component of cable tension, H, for each condition of loading. Once this is found the rest is simple, and we may proceed directly to moments, shears and deflections without further difficulty. It has been shown above how this value of H can be found for the more simple conditions of uniform loading over the whole of any or all spans. Unfortunately the loading criteria for maximum moments and shears in the stiffening trusses are not generally susceptible to a similar semi-geometrical method of treatment. In the former cases it will be noted that the cable curves were single parabolas corresponding to the uniform loads over the full length of each span; now, however, with loads covering only a part of the spans the line of the cable in such a span becomes two or sometimes three parabolas having common tangents at the points of change in load. This would render accurate solutions for lengths extremely difficult. Furthermore, the determination of the share of the loads carried by the cables would become very complicated. Such a method of attack, desirable as it may be, is not adaptable to the design of the trusses. We, therefore, have recourse to that most useful of all theorems of mechanics in dealing with indeterminate structures, namely, the theorem of work. By equating the work done by the suspender forces acting on the cable to the work done by the internal stresses in the cable integrated over the entire bridge, we are enabled to derive expressions for H in terms of the external loads on the bridge. Since the trusses co-operate with the cables in carrying live load, the equations for H are functions of the truss stiffness and the cable stiffness. The truss stiffness finds expression in terms of its moment of inertia and the modulus of elasticity of its metal, while the resistance of the cable to distortion, or its stiffness, is found in terms of its stress and its modulus of elasticity.

Erection

Theoretically the cables must be placed during their erection so that the bridge when completed will hang in or very near its correct position at a given temperature. Practically, we know that this ideal condition will probably only be approached. Certain phases of the problem are more or less beyond our control: Such as the modulus of elasticity of the completed cables, the non-uniform distribution of dead load, and the actual absolute span lengths. However, we know these physical constants fairly well and the effect of errors in them is usually small.

Let us progressively reverse the process of erection and see what part the cable plays therein. With the bridge in its final dead-load condition the cables hang in the shape of equilibrium polygons, under the effect of the vertical suspender forces distributed uniformly along the span. As these forces are all evenly spaced and are of the same amount (an assumption which is very near the truth: The maximum variation from the average being less than 5 per cent) the vertices of these equilibrium polygons will form in each case a definite mathematical curve—the common parabola. The exact length of the cables hanging in such curves can be determined. If now the weight of the entire suspended structure be removed and the cables left bare, they will shorten because of this relief of load and stress, and will hang in smooth curves under the sole effect of their own weight. The cables having a constant sectional area, this weight will be distributed uniformly along their own length, and they will therefore each have the configuration of a definite mathematical curve—the common catenary. This curve, like the parabola, gives an exact length of cable. The condition of catenary cable represents the cables in their position after they have been strung and before the dead load of the suspended structure has been hung upon them. In this state they are considerably higher at the centre of the spans than when they were fully loaded, and this amounts to seven feet in the main span for normal temperature, though it may be much more for lower temperatures. This serves to illustrate the magnitude of the motions that are involved, and which must be predetermined to a relatively fine degree.

The correct length of cable to be used in each of the spans is determined by setting definite points on the cables at prefigured elevations, and not by physically measuring off calculated lengths of wire. For convenience these points are taken at the mid-span of the cables. In doing this we are simply fixing a third point on a curve, the law of which gives us the relations between length, span and load.

The erector in the field does not set the cable as a unit, but as sixty-one individual units or strands. He must have a means of readily determining the correct elevation at which to set the first strand whatever the condition of span and temperature may be at the time. When the first strand has been set and adjusted, the remaining strands are set with reference to it; and so the question of how close the cable will come to its correct position revolves about the exactness and care with which the first strand is placed. Consequently a comprehensive sag chart which gives the elevations at mid-spans for varying tower deflections and a wide range of temperatures is prepared.

While the strands are being strung they are supported in temporary sheaves on the towers and anchorage bents. They are then free to take a position of equilibrium dependent upon a balance of their total tensions on both sides of these sheaves. (Compare this with the equality of H's which is the criterion for the balancing of the strand after it has been laid in the saddle.) This is called the free strand. Computations have to be made in order to see whether or not it will foul the foot-bridges, and so interfere with the stringing of the wires. At once we know the total length of this strand from anchorage to anchorage: It is equal to the length of the unloaded cable less a correction. This correction provides for the difference in length along the centre line of the unloaded cable and that along the centre line of the particular strand in question. We also know the horizontal spans because the tower deflections are given. First, we assume a strand tension at the support, or sheave, and from this and from the known span and weight of the strand we compute its length in the centre span. One-half the difference between this length and the over-all length, which is known, will give us the length of strand in the side span, and, reversing the process of calculation used in the main span, we solve for the strand tension on the side span of the sheaves. A comparison of this tension with that assumed for the main-span portion of the strand will undoubtedly show a variation, and a second and possibly a third trial will be necessary before the required balance is obtained. Hyperbolic functions form very useful "mathematical tools" for solving this problem.

Reference has frequently been made to the fact that the horizontal component of cable tension, H, is constant and equal in the cables of all three spans. This assumption would be true if the cables were supported on frictionless rollers where they pass over the towers, or if the towers themselves had frictionless hinges at their base. As neither of these conditions prevails here, this assumption of equal H's is only approximate. The towers offer considerable resistance to the horizontal motions sought by the cables while reaching a balance under load. These two systems, the cables and the towers, will resist any horizontal motions imparted to them in proportion to their relative stiffness. In stiffening truss analysis and in tower motion determination, where the cables are fully loaded, the effect of this differential H is small and fortunately it may be neglected. Indeed, by neglecting this additional force we are on the safe side. In the analysis of the unloaded, or the bare cable, it cannot be ignored, for it is relatively large in comparison with the forces then being dealt with. In the design of the tower it was the all-important force.

If we consider the final point of attachment of the cables to the towers we see that the horizontal forces intersecting at this point must always be in balance, or motion will result. In other words, there is a definite position of equilibrium for this point that is compatible with a balance between the H's in the main- and side-span cables, and the horizontal compelling force P which represents the stiffness of the tower. With the cables in their maximum dead-load position this point of equilibrium is by hypothesis five inches shoreward from the position of the straight or unflexed tower. Let us suppose now that the saddle is on rollers. The point of intersection of the side- and main-span cables will then be free to take its balanced position independently of the resistance of the tower. When load is removed from the cables this balanced position will be displaced shoreward, and for the condition of the unloaded cables will become 18 inches from the vertical. While laying each strand in the saddle and while adjusting it to the proper sag, its unrestrained position in the sheaves is such that the point that is to be placed over the centre line of the tower is found to be a few feet down along its length in the side span. It is therefore necessary to pull a certain amount of each strand over into the main span when it is dropped into its correct position in the saddle. If the distance that a strand is pulled becomes too great, the strand will slip in the saddle. The full 18 inches in our case was too great, and therefore it was reduced to 7 inches by pulling the towers back 11 inches by means of independent guy ropes before erection was begun. This gave a strand friction of 9 per cent, and was found to be ample to prevent slipping.

An interesting and detailed analysis was made of suspender lengths. It was desirable to hang the stiffening trusses very close to their elevation as designed. In suspension bridges this is generally done by adjusting the suspenders, as the need may require, after the trusses are hung. Because there was no facile means of adjusting the length of these ropes after they were in position and after the trusses were hung from them, an attempt was made to establish their correct length from a comprehensive collection of field data. Numerous tests of the wire rope were made and analyzed, and a representative stretch factor was obtained with which to compute the elongation of the suspenders which would occur when the dead load of the structure came upon them. The length of the suspenders to be cut was calculated by using these stretches and by basing all figures upon theoretical elevations for cable and truss profiles. These results were sent to the field, the ropes were laid out, measured off, cut and socketed, and then remeasured. The variations involved in these field operations were thereupon transmitted back to the office. Here, in the meantime, data worked up from a field survey of the completed cables gave us the predicted elevations at every panel point along the centre line of the cable in its final dead-load position; periodical reports from the shops where the stiffening trusses were being assembled also furnished us with the data from which we established the actual profile of the trusses in their fabricated position. These data even included the small shop errors in elevation that were made in assembling the suspender connection angles to the trusses. Finally, the variations in setting the cables and fabricating the trusses, combined with those made in actual cutting and socketing the ropes, were translated into terms of a correction in length for each and every suspender—596 in number. This length correction was physically made in the field by shimming between the suspender sockets and bearing angles on the trusses. The almost contemporaneous progress of the work of truss fabrication, suspender cutting, and even truss erection made cooperation very essential in carrying out this program.

At the time of pulling back the tower columns in preparation for cable erection, it was found convenient to check the tower stiffness. The field measurements consisted of observations of the sags in the guy-ropes used in pulling the towers back, the sags in the foot-bridge cables, and the temperature. The calculation required the finding of the net horizontal force at the top of the tower, and the portion of the reported deflection due to this force (the vertical load is responsible for some of the deflection). The results showed an average stiffness of 19,000 pounds per inch of deflection compared with the theoretical amount of 20,800 pounds per inch. This is a difference of 9 per cent. When the wide, possible variations in load and temperature combined with the difficulties attending the physical measurements are considered, this might be classed a very close check.

When the cable had been completely strung, and while it was still in its hexagonal, uncompacted state there was an opportunity offered for checking the actual lengths of wire in the individual spans. Field measurements included observations of sag (obtained by surveying elevations) tower deflection and temperature. The computations consisted of finding the catenary curve fitting these conditions. A parallel set of observations and calculations were made after the cable had been compacted to its final circular shape. The results of both of these checks are shown in Table I.

TABLE I

Cable Lengths from Field Observations

Date of Observation	Philadelphia Side Span	Centre Span	Camden Side Span
		Theoretical Lengths	
	780.60 feet	1791.60 feet	780.60 feet
		North Cable—Uncompacted	
December 23, 1924.....	780.63 feet	1791.60 feet	780.60 feet
December 30, 1924.....	780.61 feet	1791.75 feet	780.56 feet
		North Cable—Compacted	
February 6, 1925.....	....	1791.60 feet	....
February 25, 1925.....	780.64 feet	....	....
March 5, 1925........	....	....	780.60 feet
		South Cable—Uncompacted	
December 23, 1924.....	780.58 feet	1791.68 feet	780.63 feet
December 30, 1924	780.57 feet	1791.73 feet	780.61 feet
		South Cable—Compacted	
February 6, 1925.....	....	1791.77 feet	....
February 25, 1925.....	780.61 feet	....	....
March 5, 1925........	....	....	780.60 feet

With these check analyses on the unloaded cable for a basis, a prediction of final tower positions and cable elevations for maximum dead load was made. The actual observed catenary cable lengths were increased by the theoretical stretches occurring between the two conditions of loading. This gave the probable length of parabolic cables under full dead load. It only remained to find the horizontal spans required to balance the H's in the three cables. Table II shows the results obtained. Scanning this table we might interpret it as meaning that, from the field data on hand at the time, we would expect the cables for the completed bridge to hang at about the right elevation in the side spans, and about 1½ or 2 inches high in the centre span; and that we would expect the towers to be a fractional part of an inch shoreward from their designed position except in one case, the north Philadelphia tower leg, which would be less than an inch riverward from this position. All of this would be predicated upon the assumption that the total stretches and changes in load between the two conditions of unloaded and loaded cables would be as theoretically computed, and that the distribution of dead load would be uniform.

We have seen how important a part cable calculations play in the design of the towers, stiffening trusses and cables, and how necessary they become in the planning and carrying out of erection. Mathematical complications, myriads of figures, and days and months of wearisome labor were involved. Altogether they form only one phase of the bridge design. Other phases are equally essential to a strong and economic and esthetic bridge.

TABLE II

Predicted Cable Elevations and Tower Deflections for Maximum Dead-load Conditions from Field Observations

		Cable Elevations	
	Centre of Philadelphia Side Span	Centre of Main Span	Centre of Camden Side Span
Theoretical elevations............	+219.80 feet	+176.80 feet	+219.80 feet
From observaitons { North cable..	219.78 feet	176.93 feet	219.79 feet
From observaitons { South Cable..	219.80 feet	176.97 feet	219.80 feet
		Tower Deflections	
	Philadelphia Tower		Camden Tower
Theoretical tower deflection......	—5 inches		—5 inches
From observations { North column	—4⅝ inches		—5⅛ inches
From observations { South column	—5⅛ inches		—5⅛ inches

Building Highways for Safety

By PROF. S. S. STEINBERG,
University of Maryland

THERE are to be found on our highways today more than twenty million motor vehicles, sufficient in number to supply one to each family in the United States. It is predicted that in seven years we will have one vehicle to every four persons. sufficient to furnish one to each individual that is old enough to reach the steering wheel.

Although we are improving our highways at a rate never dreamed of before, we cannot keep pace with the demands created by the enormous increase in vehicles. Last year alone, more than 4 1/3 million motor vehicles were produced, an increase over the preceding year of 20%. During this period about 40,000 miles of highways were surfaced, an increase of but 11%. It is then evident that we are producing and absorbing motor vehicles twice as fast as we are providing roads upon which they may conveniently travel. This condition has brought about a traffic congestion on our streets and roads so acute that we have come to realize that one of the major problems facing the country today is to provide sufficient road and street capacity to permit safe operation of our vehicles.

The American Road Builders' Association has selected as the chief topic for discussion at its next annual meeting, to be held at Chicago, from January 10 to 14, 1927, the matter of highway safety. It is the opinion of the members of this organization that safety on the highways will be best promoted by building wider roads; by a more extensive improvement of our secondary roads, thereby relieving the main highways of considerable local traffic; by properly posting warning signs where traffic hazards cannot be eliminated; and, finally, by securing the adoption of a uniform traffic code in all the states.

Many state highway departments, as for instance Maryland, Connecticut, and Pennsylvania, as well as a number of large cities. are making a careful study of the causes of accidents occurring on their highways, and are thereby enabled to remedy unsafe conditions. Accident records are kept by means of a highway map on which a colored pin is inserted at the spot on the map where an accident has occurred. A different colored pin is used for each type of accident. An accumulation of pins shows in a graphic manner the location where a construction change is needed.

In the interest of safety, highway engineers are relocating the main roads to eliminate curves, to avoid railroad grade crossings, and to reduce steep grades. Incidentally, these relocations save distance, avoid costly bridges and mean large benefits to the motorist in the cost of vehicle operation. For instance, in Illinois a road 150 miles long was relocated almost entirely throughout its length, thereby saving 30 miles of unnecessary distance and eliminating 31 grade crossings. The saving in vehicle operation to the citizens of that state, as a result of this improvement, is estimated at one million dollars a year.

The frequency of highway accidents resulting from traffic congestion in the vicinity of large industrial centers, and on main thoroughfares, is leading to the construction of what is known as the "super-highway," or to provide alternate routes. Foremost of the super-highways is the one out of Detroit. This road has a total width of 204 feet, with two separated roadways 44 feet wide, each carrying one way traffic. On each of the four-track roadways horse-drawn traffic keeps to the right hand curb; slow moving heavy trucks outside them, and automobiles in the two other lanes. In addition, space is provided between the roadways for rapid transit trolley lines, and provision is made for motor parking, as well as for pedestrians.

One of the developments of the future may be separate roads for freight and for passenger service; a low grade, heavily constructed road for trucks and a less expensive type for passenger vehicles. A road planned primarily for trucking between Boston and New York is now under construction.

An important step to promote highway safety was recently taken by the United States Bureau of Public Roads in co-operation with the State highway departments, in adopting uniform standards for warning signs to be used throughout the country. The motorist will no longer be confused by a multiplicity of signs of various designs and degrees of legibility. Hazards will be indicated by signs which will be uniform in all states and which will plainly indicate the kind and degree of danger. The new signs make use of a system of different shapes, thereby increasing their value at night. The shape indicates the degree of hazard and if the motorist cannot read the legend, the shape will tell him the degree of caution required.

In this system a round sign indicates a railroad crossing; a diamond-shaped sign calls for a reduction of speed, as at a curve or narrow bridge; an octagon indicates a complete stop, or necessity for proceeding slowly with car under control; a square sign indicates a lesser degree of caution than any of the others, such as a school zone or a side road. Twenty states are now actually engaged in erecting these standard warning signs, and the other states have signified their intention of erecting them in the immediate future.

Applications of Radio in Air Navigation[*]

By DR. J. H. DELLINGER

Chief of Radio Laboratory, Bureau of Standards

RADIO is being used for many purposes, some of them more appropriate than others. The major uses for which radio is appropriate include broadcasting, transoceanic telegraphy and telephony, communication with ships at sea, and communication with aircraft. The applications to aircraft are now going on with great rapidity, and are similar in principle to the marine uses but very different in the actual working out. Both for marine vessels and for aircraft, radio provides the ideal means of exchanging messages, of providing navigational aids, and of remote control. There is but little field of usefulness for remote control except in military practice and it will be left out of consideration in this discussion.

In its important functions of carrying messages, and of providing aids to navigation, there are clear lines of differentiation in the evolution of radio for marine and for air use. These depend largely on the essential differences in speed, size, and weight limitation. Another difference is the special problem of landing which the airplane offers. Whereas an airplane is a small, light, rapidly-moving object, a marine vessel is, from the radio viewpoint, but little different from an island. It can carry any type and amount of radio apparatus, and can be as leisurely as it pleases in using it. Lighter-than-air craft is intermediate between the airplane and marine vessel in its radio requirements. It can use any of the radio aids that an airplane can and some of those adapted to marine vessels in addition. Airplanes are principally in view in this discussion, particularly because the problems which require attention at the present time arise out of the need of developing radio aids to airplane navigation on the existing and rapidly developing civil airways.

Radio Telephone Communication.

It is generally agreed that the primary and most urgently needed application of radio in air navigation is simply that of communication. The great problem of the airplane at the present time is that of landing. The maintenance of communication so that the pilot, regardless of weather conditions, may be kept advised of suitable landing places is the first requisite. Comparing airplane communication with that applicable to marine vessels, it may be stated that aircraft require telephony instead of telegraphy, and that the communication be at higher frequencies, and, generally speaking, over shorter distances than for marine vessels. The use of continuous-wave radio telegraphy is inherently a more economical method of communication than radio telephony, and is the natural means of communication for ships. This, however, requires the use of an operator trained in the telegraphic code. Most airplanes now have no crew other than the pilot, and this condition will doubtless be true for a long time to come. It is not to be expected that the pilot will also be a telegraph operator and it therefore follows that radio telephony rather than telegraphy will be the system used on aircraft. Higher frequencies will be used than in marine communication because of the relatively small size of airplanes. It is inconvenient and undesirable to use long antennae on airplanes. Short antennae work most efficiently with high frequencies. It is therefore to be expected that relatively high frequencies will become standard for aircraft radio telephony. I mentioned that aircraft communication is characterized by shorter distance work than marine communication. This is true both because of the weight limitation on transmitting, or receiving, apparatus carried on the airplane and, also because of the interference to reception produced by the airplane engine ignition system. A shielding system can and should be used on all airplane engines which largely eliminates this interference, but the perfection of this shielding is limited by the additions to the total weight. It may be said furthermore that, there is no good reason why great distances need to be covered in aircraft communication. Here we have an essential advantage over marine navigation. On the airways of the country radio telephone transmitting and receiving stations can be placed at convenient and relatively short intervals. These will be advantageous for the aircraft and incidentally will be a more economical system than the use of a very few stations of great power placed great distances apart. In this respect aircraft communication has an advantage over marine communication.

It is generally agreed that communication to the aircraft is much more important than communication in the other direction. It will add immeasurably to the peace of mind of the pilots, and the safety of flying, when all airplanes carry radio receiving sets and there is an adequate system of ground stations telephoning information as to weather, landing conditions, etc. As the airways develop and passenger carrying becomes more common, there will be increasing use of radio telephony from the aircraft as well. Two-way communication will, of course, be a great advance. There is a great variety of technical problems involved in this and all the other applications of radio to air navigation. Some of them require research and engineering work yet to be undertaken. I can do no more than mention a few of those concerned in the proper development of telephony to and from aircraft. They include the technique of shielding ignition systems, the choice of type of receiving sets, the type of power supply for transmitting sets, and the all-important problem of the assignment of frequencies.

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[*] Address before the Engineers Club, the Aero Club of Pennsylvania and the American Society of Mechanical Engineers, Aeronautical Division, Sept. 7, 1926.

Directive Beacon

Besides solving the problem of communication with aircraft, it is obvious that radio furnishes an instrument of navigation. During clear weather, and for flying below the clouds, a pilot needs no navigational instrument other than his eyes for he can see the ground in the daytime, and the airways will be provided with lights for night flying. When the ground is obscured by fog, however, or when the aviator wishes to fly at great elevations, radio is the only navigational aid available. In making use of the directional properties of radio there is a marked difference between the trend for air navigation and for marine navigation. Marine vessels are finding the radio direction finder of the greatest assistance as an aid to navigation, particularly in fog, but there is little tendency to equip airplanes with direction finders. On account of the weight limitation it is highly desirable that means be provided to guide airplanes on a course without requiring that they carry any direction finder, or any apparatus other than the receiving set which will be carried for other purposes anyhow. This requirement is met by the directive radio beacon. The most promising beacon of this type and the only one which has been developed into a practical form is the double-beam directive beacon which was developed by the Bureau of Standards for the Army Air Service five years ago. This beacon sends out two directed radio beams, continuously transmitting on each of the two beams a characteristic signal. When near the axis of either beam the pilot listening to the signals, with an ordinary receiving set, hears the signals from that beam much louder than those from the other. Half way between the two the signals from the two beams are heard with equal intensity, an equi-signal zone is thus marked out and provides a convenient and reliable means of flying a given course. A beacon of this type is in use at McCook Field, and in the form there used the signals in the two beams are so adjusted as to interlock when the aviator is on the equi-signal zone, that is, in this zone a continuous dash is heard instead of a series of dots and dashes which are heard when off the zone.

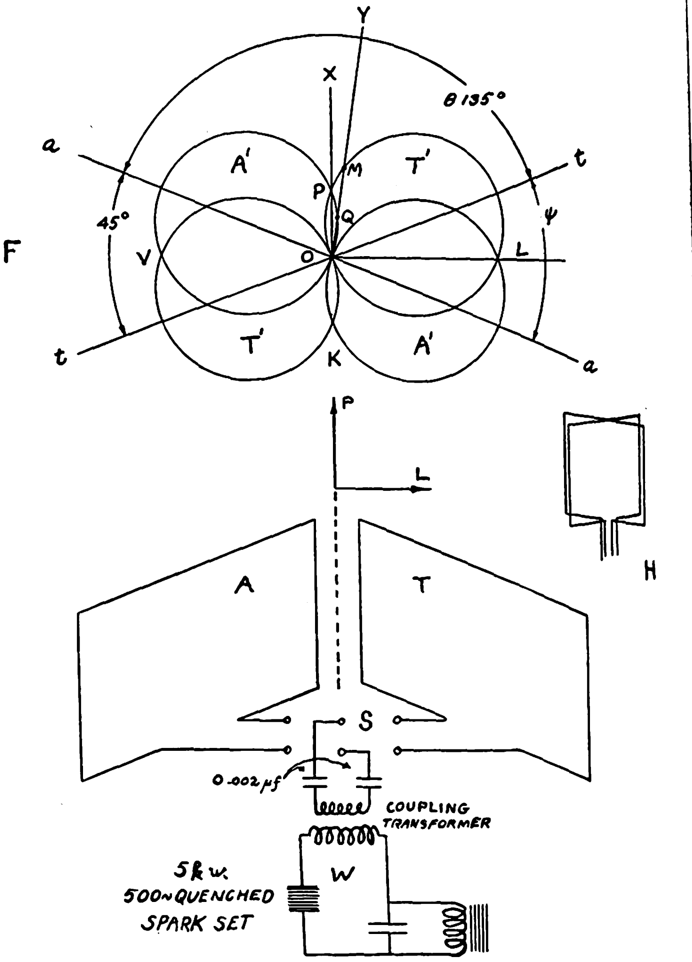


FIGURE 1

PRINCIPLE OF THE DOUBLE-BEAM DIRECTIVE BEACON. IN UPPER PART OF DIAGRAM THE A AND T PAIRS OF CIRCLES SHOW IN POLAR COORDINATES THE RELATIVE INTENSITIES OF RADIATION FOR EACH TRANSMITTING COIL, A AND T, IN ALL DIRECTIONS. ON THE BISECTOR OX THE INTENSITIES FROM THE TWO COILS ARE EQUAL.

It seems clear that this radio beacon will be used to mark the routes between landing fields. It is usable regardless of weather conditions. It assists in solving the problem of flying during poor visibility, as the flier can fly above the poor visibility level. The beacon signals serve as well at high as at low altitudes.

It is possible that this beacon method may be modified by providing a simple device which can be used with the receiving set on the aircraft, having a pointer which indicates visually the position of the aircraft, on or off the course. It is understood that the aviators are satisfied to use the aural method since the pilot has to wear a helmet anyway and since a helmet has been devised in which the presence of the ear phones adds no discomfort. In spite of this it may be that a visual indicator, now under development, would be a great improvement. In the aural method there is some difficulty in distinguishing the different types of signals, on and off the equi-signal zone, because of the inevitable background of clicks and noise of various kinds. While a pilot would become skilled in the use of these signals, it nevertheless is a slight strain upon him, and if the visual indicator is developed successfully it will tend to reduce the strain.

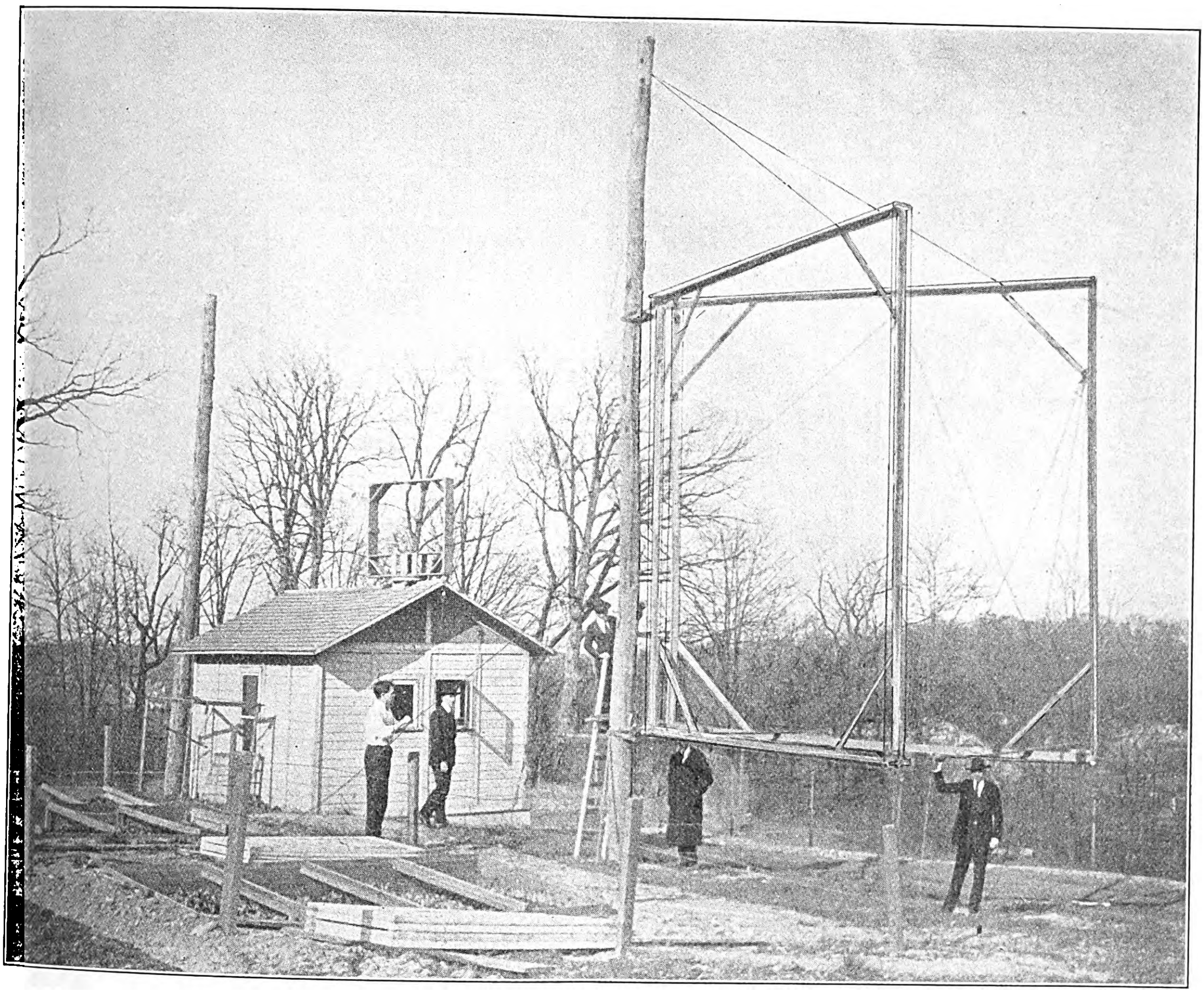


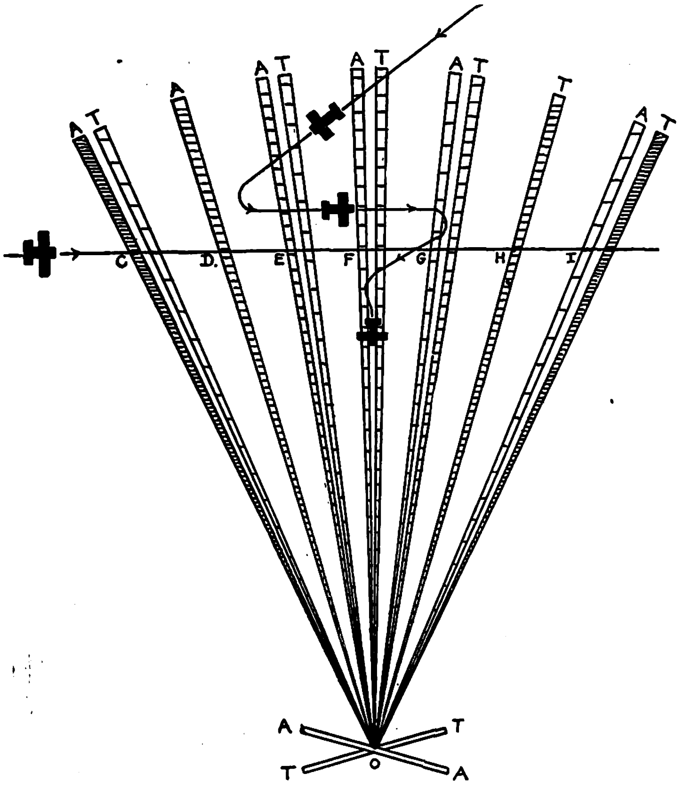
FIGURE 2

EXPERIMENTAL COIL ANTENNAE SUPPORTED ON POLE IN ORIGINAL EXPERIMENTS ON DOUBLE-BEAM DIRECTIVE BEACON.

This radio beacon is undoubtedly practical, but a number of problems will arise when a large number of them are in use and when there is a necessity of marking out several courses radiating from a given airport or beacon station. The device can serve as a beacon for all directions by continuously rotating the equi-signal zone together with the use of a stop-watch on the aircraft, but this would be a complicated system and would be so much less simple in use that its utility is doubted. By rotating the equi-signal zone in steps, however, setting it for brief periods successively on the several courses desired, a satisfactory service can probably be worked out. When there are many of them in use, it may be necessary to provide special means of recognizing the signals when set on different courses and those of different beacon installations. The limitations of radio, particularly the additions to interference made by every added radio beacon, or installation of any kind, need to be kept constantly in mind.

Marker Beacons.

A directive beacon of the type I have described is sufficiently well developed to ensure that it will be used on the civil airways of the United States. It serves effectively to guide the aviator along his course. It is subject to the limitation, however, that it gives no indication as to the distance covered, or as to the particular part of the route which is passed at any given time. This lack can be remedied by the establishment of very low-power radio transmitting stations at intermediate points to serve as localizers or markers of those points. These low-power non-directional beacons will give a characteristic signal which will be heard and recognized by the aviator during a short interval when he is near and over these beacons. They will not mark a line of direction but simply mark a distance somewhat as mile posts on an ordinary road. Very simple radio transmitting outfits are being designed for this service and it is be-


A
T
A
A
T
A
T
A
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T
A
T
C
D.
E
F
G
H
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T
O
A

FIGURE 3
METHOD OF GUIDING AIRPLANES BY DOUBLE-BEAM DIRECTIVE BEACON. AMOUNT OF CROSS SHADING IN EACH BEAM SHOWS THE RELATIVE INTENSITY OF SIGNALS RECEIVED THERE FROM THE TWO TRANSMITTING COILS OF THE BEACON. THE AIRPLANE RECOGNIZES THE CENTER COURSE BY THE EQUALITY OF INTENSITY OF THE A AND T SIGNALS.

lieved that they will supplement the directive radio beacon in a most effective way.

Field Localizers

While the radio beacon will adequately direct flight along the course, it does not in its present form provide a positive means of determining the exact location of the landing field, or of landing in fog. It serves in a general way as a field localizer since the width of the equi-signal zone grows considerably narrower as the field is approached. It is quite possible, however, that it can be developed, or supplemented, so that the character of the signals, or of the equi-signal zone, shall be particularized over the landing field, and the exact location of the field definitely marked out. It is quite possible that further work on antenna systems for the beacon will accomplish this desirable purpose. A satisfactory field localizer would assist the aviator to a position directly above the field, and direct him to a safe landing.

A new method now used, and one which is capable of further development, is the simple one of having an observer on the landing field listen for the noise of the airplane and estimate its height above ground by the noise, sending this information by radio to the pilot. This involves utilizing the services of the ground personnel so that they can serve as the eyes, or ears, of the pilot for landing purposes. This same procedure may perhaps be used to aid in keeping the aircraft on a route, through listening at intermediate stations and indicating to the flyer that he is passing a definite point, or field, on the route.

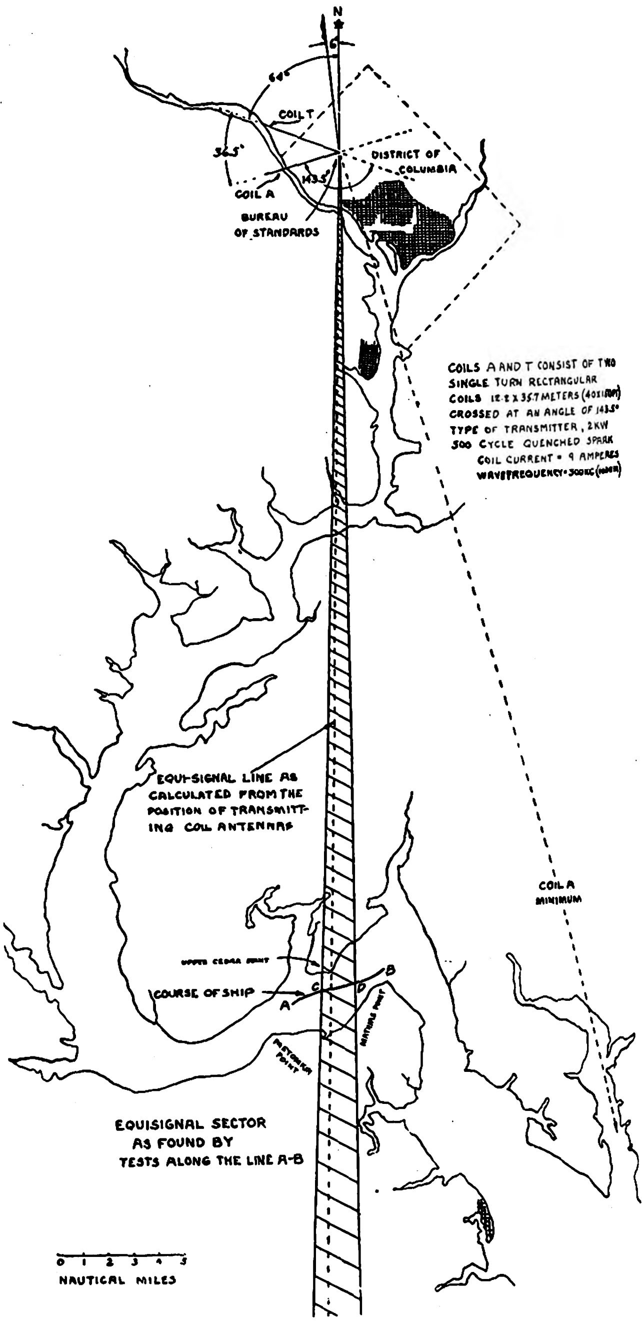

N
6°
64°
COIL T
36.5°
COIL A
143.5°
DISTRICT OF COLUMBIA
BUREAU OF STANDARDS
COILS A AND T CONSIST OF TWO SINGLE TURN RECTANGULAR COILS 12.2 X 35.7 METERS (40X117 FT) CROSSED AT AN ANGLE OF 143.5° TYPE OF TRANSMITTER, 2KW 500 CYCLE QUENCHED SPARK COIL CURRENT = 9 AMPERES WAVEFREQUENCY = 300KC (1000M)
EQUI-SIGNAL LINE AS CALCULATED FROM THE POSITION OF TRANSMITTING COIL ANTENNAS
COIL A MINIMUM
UPPER CEDAR POINT
COURSE OF SHIP
A
C
D
B
MATHIAS POINT
PISTOMAN POINT
EQUISIGNAL SECTOR AS FOUND BY TESTS ALONG THE LINE A-B
0 1 2 3 4 5
NAUTICAL MILES

FIGURE 4
RESULTS OF ORIGINAL TRIAL OF DIRECTIVE BEACON. A SHIP IN THE POTOMAC RIVER LOCATED THE BEAM AS SHOWN, AND FOUND THE ZONE OF EQUAL SIGNALS TO HAVE THE WIDTH CD.

Several types of electrical field localizers have been developed in an experimental way. One of these which was worked out by the Bureau of Standards a number of years ago, at the request of the Air Mail Service, involved the use of a coil of wire extending around the confines of the landing field carrying 500-cycle alternating current. Using an amplifier, an aviator could hear this signal when over the field up to a height of several thousand feet. An arrangement of smaller coils carrying radio-frequency currents was also developed which accomplished about the same result.

None of the possibilities in the way of field localizers have been put in practical use. Perhaps the chief drawback to all of the plans, so far developed, is that special attention, or activity, is required on the part of the aviator. The object in view is so important that further work should be done on this problem, but the method which will eventually be adopted must be one which requires very little complication of apparatus and a minimum of special activity on the part of the aviator.

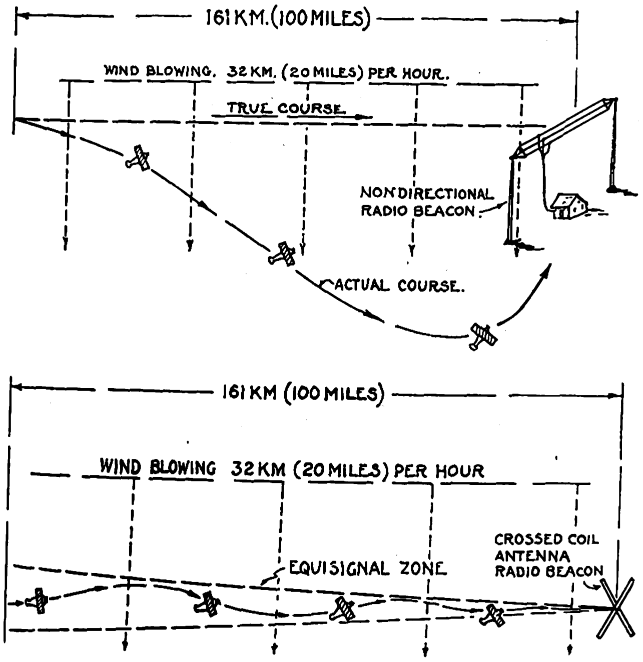

161 KM.(100 MILES)
WIND BLOWING. 32 KM. (20 MILES) PER HOUR.
TRUE COURSE.
NONDIRECTIONAL RADIO BEACON
ACTUAL COURSE.
161 KM (100 MILES)
WIND BLOWING 32 KM (20 MILES) PER HOUR
EQUISIGNAL ZONE
CROSSED COIL ANTENNA RADIO BEACON

FIGURE 5

COMPARISON OF EFFECT OF WIND DRIFT IN NAVIGATION BY DIRECTION FINDER (UPPER DIAGRAM) AND BY DIRECTIVE BEACON (LOWER DIAGRAM).

Direction Finders

Lighter-than-air craft, and the larger airplanes, will doubtless carry direction finders. The extra weight and complication precludes their use generally on the smaller airplanes. Aircraft which do carry them use either the simple rotating-coil type, as used on ships, or a special double-coil type which has certain advantages in operation through interference from the ignition system.

This interference necessarily makes direction finding on airplanes less practical than on the ground. On account of this there has been some development of the reverse system, in which direction finding stations are provided at certain points on the ground for determining the position of aircraft which have transmitting sets but do not carry a direction finder. England has two such stations for locating position of aircraft, one in the north and one in the south of that country. As aircraft move so fast it is desirable to have the aviator make frequent reports to the ground direction finders, so that they can keep a plot of the craft's course, and know the approximate position at all times. Trouble on aircraft can occur so quickly that in some cases the flyer would only be able to report that he was landing; there would be no time for a bearing and it would be necessary to send aid, or search, in accordance with the plotted course. In some cases the reports would merely cease, and failure to arrive in due time would make the plot a valuable reference point.

The use of direction finders is an alternative to the directive beacon system which I previously described. Aircraft which travel only fixed courses, marked out by radio beacons, would have no use for direction finders. Those which fly over courses not provided with the beacons, however, will find radio direction finding a valuable aid.

Landing Altimeters.

Work with aids to airplane navigation has first, last, and all the time the problem of landing as its chief difficulty. Much thought and experiment have been spent on methods to facilitate landing in fog, but I find that aviators declare that no mechanical instrument could ever give them sufficient confidence to make an actual landing when the ground was invisible. The radio beacon can guide a pilot to the landing field, its location and outline can be given him by a field localizer device, but there still remains the problem of indicating to him the exact distance above ground during the last few feet of descent and actual landing. Various methods have been proposed or tried, to give an indication of the exact distance above ground during this critical period when the airplane is settling to earth. All the methods offer great difficulties. They include electrical capacity variation, sound reflection, and radio wave reflection. The first of these is known as the capacity altimeter. It was developed by the Bureau of Standards and the Air Service in 1922, and is as promising as anything now known. Two wire structures are provided on the airplane supported as far apart as possible from the ends of the wings and as far below the airplane as feasible; the instrument utilizes the variation of electrical capacity between these two structures as the ground is approached. The variation of capacity produces variations in tuning of a radio circuit, which is indicated by an instrument. This instrument can be calibrated in feet above ground, and is effective in the critical range between ground level and some 30 or 40 feet up. It is still a question, however, whether the additional complication of the aircraft receiving equipment, and the delicacy of this type of measurement, will permit this to be developed into a practical operating method.

Conclusion.

The foregoing has dealt only with the direct use of radio in connection with aircraft operation. The subject of the necessary communication between airports, and other points on the ground in connection with aircraft operation, is conceived as an entirely separate subject. In principle such communication can be done entirely by means of wire telegraphy and telephony, and radio would not necessarily be required at all. The uses of radio which I have sketched are uses to which nothing except radio is adapted.

In carrying out its newly assigned responsibilities to provide aids to air navigation on the civil airways, the Department of Commerce has concluded that radio aids are indispensable. As the first step in establishing these radio aids the Bureau of Standards is at present engaged in setting up a model installation. In connection with this, experimental research work is being undertaken on those features of the radio aids which are not yet available in sufficiently perfected form. It is clear that the airways must be provided with a system of radio telephone transmitting stations, and directive beacons, at certain intervals. At smaller intervals between the directive beacons, probably every 25 miles, are to be located the marker beacons. It is not yet certain whether the beacons will operate by means of an audible or a visual signal on the airplane, and the determination of this is one of the principal objects of the investigation now in progress.

It would be impossible to prophesy the limit of possibilities of radio in connection with air navigation. In addition to radio telephony, the directive beacon, and the marker beacon, there remain the further possibilities of field localizers, direction finders and landing altimeters. Research is in progress on these additional aids. They all offer difficulties, but doubtless will be eventually worked out and adapted in various forms to aircraft use. In any event there is every reason to believe that radio will have a steadily increasing part in expediting, and increasing the safety of, air navigation.

NEW BOOKS

BOOK REVIEWS

Drainage and Flood-Control Engineering—By G. W. Pickels, Assistant Professor of Drainage Engineering, University of Illinois. 450 pages, 6x9. Illustrated. $4.00.

This book covers all phases of the drainage engineer's work from the drainage of small areas of farm land by tile underdrains to the reclamation of large areas by flood protection, by drainage through open ditches and by pumping. It sets forth the principles that control the selection of a comprehensive drainage system as well as the principles which govern the design of the details.

Handbook of Building Construction—Editors-in-Chief—George A. Hool, Consulting Engineer, Professor of Structural Engineering, University of Wisconsin and Nathan C. Johnson, Consulting Engineer, assisted by forty-six specialists. Two volumes (not sold separately). 1,474 pages, 6x9, flexible. Illustrated. $10.00.

Modern reference data for architects, designing and constructing engineers and contractors. The book covers thoroughly the design and construction and types of buildings with their mechanical and electrical equipment. Every detail of practical construction is considered. This handbook is complete and thorough in every detail.

Laboratory Manual of Testing Materials—Wm. K. Hatt, Prof. Civil Engineer and Director of Laboratory for Testing Materials, Purdue University. H. S. Scofield, Asst. Professor Civil Engineering in charge of Testing Materials, Cornell University. Third Edition, illustrated. $2.00.

A thorough revision of this widely used manual. New experiments have been added and all references to standard specifications, etc., have been brought up to date.

Design of Concrete Structures—(New Second Edition.) L. C. Urquhart, Prof. in Charge of Structural Engineering, Cornell University. C. E. O'Rourke, Asst. Professor of Structural Engineering, Cornell University. 500 pages, illustrated. $4.00.

A thorough revision of this text on the fundamentals of the latest and best practice in the designing of plain and reinforced concrete structures.

Changes and additions have been made throughout to bring the book in line with current practice and with the latest report of the Joint Committee.

A greater part of the illustrative problems have been revised and new ones added to conform to the higher working stresses now frequently allowed in specifications.

Solving Sewage Problems—By Geo. W. Fuller and James R. McClintock. 548 pages, 83 illustrations. $5.00.

A manual of modern practice in the disposal of sewage, giving particular attention to such topics as the natural purification of streams, basic design data, plain sedimentation tanks, sludge digestion processes, separate sludge digestion tanks, the collection and utilization of gas, screens, trickling filters, the activated sludge process and industrial wastes.

Ventilation of Mines—By Walter S. Weeks, Assoc. Prof. of Mining, Univ. of California. 228 pages, 116 illustrations. $3.00.

A book for the mining engineer who wishes to make a study of the theory and practice of up-to-date mine ventilation. The book presents such principles and experimental data as are necessary for the design of adequate systems of ventilation for mines, whatever their type.

ENGINEERS & ENGINEERING

DECEMBER, 1926

Vol. XLIII FOUNDED 1879 No. 12

Business and Banking

COMING into the last month of what has been in many respects a record year in business, indicators at last show visible evidence of variation in the general trend. No doubt a seasonable influence enters into the commercial picture, this being the month in which a great volume of manufactured and imported goods will be turned into cash, and as concerns retail trade which, now promises to be larger than in any preceding December, cash receipts rather than book credits; and it would be strange if, when approaching the period of "the closing of the books," there were not a general tendency toward reduced buying rather than toward the accumulation of still more goods. In fact, what has been termed "hand-to-mouth" buying was a distinct feature of 1926, and from surface indications it appears to have been a good thing. It reflects an effort, not unsuccessful, to carry on a volume business with a sharp watch on inventory, necessitating speedier work, to some degree eliminating waste, and perhaps reducing the requirement of bank accommodation.

The Guaranty Trust Company of New York has arrived at this conclusion, since its December "Survey" will say:

"In some directions the distributive movement appears to be in greater volume than at this time last year, while in others a moderate decline is indicated. The movement of railway freight, for example, has continued to exceed all previous records. * * * On the other hand, the level of commercial check payments has been alternately above and below that of last year.

"A similar tendency is apparent in the volume of sales by retail establishments.

"A definite tendency toward lower levels of activity has become evident in a number of basic industries in recent weeks. Of the numerous declines reported the most pronounced is in automobile manufacture, in which curtailment has been under way since September."

Nevertheless the present aggregate of wholesale and retail trade continues large. During the second week of November, for instance, the Department of Commerce reported the volume, as represented by check payments, larger than for the previous week or for the corresponding week of the previous year. Car loadings, while slightly less than recorded in the last week in October, were considerably greater than during the corresponding week of 1925. Contracts for new buildings show recessions but in this connection the Philadelphia News Bureau comments as follows:

"With building permits in the 500 leading cities of the United States during the last six months only slightly less than $2,500,000,000, the nation's winter building program will, from present indications, be of such magnitude as to absorb all available labor in the building crafts. While a number of wage readjustments outside the larger cities are being made on the basis of slight increases, the building situation generally is well stabilized and free from disturbing elements."

These facts represent the concensus of reports submitted to S. W. Straus & Co., from all parts of the country. Labor conditions in the building industry were summarized as follows:

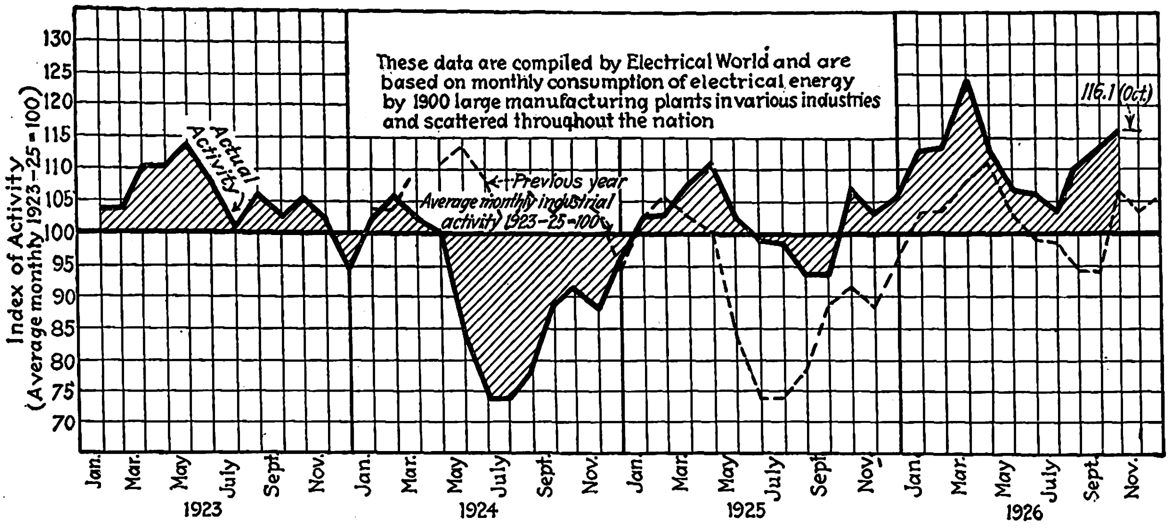
"Wage scales have reached a peak and any attempt to boost wages will be met with resistance by the building public.

"Despite numerous reports there has been no concerted action for the forty-hour or five-day week.

"Jurisdictional disputes have practically been eliminated in building labor circles.

"There is no shortage of men in the building craft with the exception of bricklayers and plasterers of which there seems to be a present deficiency of approximately 20,000 men.

"Tranquility is assured between builders and the building crafts generally, despite some difficulties yet unsettled in San Francisco and Cleveland."



"ELECTRICAL WORLD" BAROMETER OF INDUSTRIAL ACTIVITY IN THE UNITED STATES AS A WHOLE
(Data Unadjusted for Seasonal Variation)

A Curve indicating general industrial activity during the past four years, as prepared by the Electrical World, is presented here. The data for this curve is based on the monthly consumption of electrical energy, and probably come the nearest to exact of any of the so-called barometers.

* * *

"The Nation's Business" has canvassed American business for opinion in respect to the outlook for 1927. In its December issue it says that "while there is in no sense a pessimistic note in the replies as a whole, there is a note of caution, a suggestion that 1927, at least for its first half, may see some shading off."

Mr. H. M. Robertson, First National Bank, Los Angeles, replies to their inquiry saying "general business during 1927 will probably be less than in 1926, although the many strong factors preclude any serious or abrupt decline." "In Los Angeles territory strong bank deposits are at record heights and money is easy for sound commercial purposes. The demand for funds is good; the agricultural sections are receiving a satisfactory liquidation of farm credits despite lower prices in the case of several crops." Mr. A. T. Simonds, of Fitchburg, Mass., a close student of business economics, expresses the opinion that "it is good business to estimate that 1927 will not be as good as 1926. The depression may not come till 1928, but the odds are about 3 to 1 that it will come in 1927." Mr. A. L. Humphrey, Westinghouse Air Brake Corporation, Pittsburgh, is quoted "looking forward optimistically for a business at a fair average profit during the first half of 1927 equal in volume to, if not far exceeding, what we have enjoyed during the past six months of 1926." Mr. John M. Crawford, of Parkesburg, "can neither feel nor see anything but optimism in trend of business for the first half of 1927. Speculative building has been slackened by high wages. Buying of rails and locomotives is outstanding. Carloadings are extremely satisfactory, as is also the condition of the iron and steel market. * * * A good index to the situation is active distribution, insuring employment of labor at equitable wages and the fact that purchases of commodities, while individually small, have been frequent, and in the aggregate, substantial."

The foregoing reflect the tenor of eighteen replies from the nation-wide canvass of representative men in various industries.

FREDERICK CARLES.

The Year in Agriculture*

Further moderate improvement in the agricultural situation as a whole has taken place during the last year. Certain regions have suffered reverses, notably the cotton States, whose principal crop, produced in exceptional abundance, is selling at very low prices. Parts of the spring-wheat States have harvested a poor crop. Generally speaking, however, the position of agriculture is better now than it has been in any year since 1920. Livestock raisers, dairymen, and winter-wheat growers have earned good returns, and underlying conditions in the Corn Belt have improved. The year, in short, has been similar to the last few years in that it has seen marked but not uniform improvement in agricultural conditions.

Unfortunately, the recent slump in cotton prices makes it doubtful whether the crop year 1926-27 will carry forward the story of improvement at the rate established in the last few years. An average price of about 18 cents a pound for the estimated cotton crop would be necessary to yield the cotton States an income equal to that of last year. Recently the farm price of cotton has been around 12 cents a pound. While there are prospects that this extremely low price will be only temporary, it does not seem probable at this writing that returns to the cotton growers will be satisfactory. It is also true that, over much of the country, farmers are still struggling with a burden of debt and reduced buying power.

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*Extracts from the Annual Report of the Secretary of Agriculture.

The Tariff and the Farmer

It will help us to estimate the significance of the tariff in relation to agriculture if we consider not only how it works now but how it is likely to work in the near future. There is no doubt that tariff protection is most effective on commodities produced exclusively for domestic consumption. When there is a large export surplus of any article, the price of that surplus in export trade tends to set the price for the domestic supply as well. This, of course, is a truism. Frequently, however, its full application to agriculture is overlooked. It is commonly assumed that agriculture is the only American industry operating largely in foreign markets. Manufacturing industry, with its supposed independence of world conditions, is believed to be getting the last possible ounce of benefit from the tariff, unaffected by the difficulty of disposing of its surplus.

This may have been largely true in the past. Even today industry does a smaller proportion of its business abroad than does agriculture. In the near future, however, the position may be reversed. American agriculture is moving steadily toward a position in which the home market will absorb more and more of its total production, whereas industry, on the other hand, is becoming increasingly dependent on export sales. In a comparatively short time agriculture is likely to have more need of effective tariff protection than industry.

A few figures will illustrate this significant tendency in our economic life. In 1901 our agricultural exports made up 65.2 per cent of our total exports. By 1913 the proportion had dropped to 43.6 per cent. There was an increase during the war to 50.6 per cent in 1919, but after the war the downward trend was resumed. In 1925 our agricultural exports dropped to 44.2 per cent of our total exports. In the year ended June 30, 1926, the proportion was only 40.6 per cent.

Meanwhile industry has been steadily increasing the proportion of its export trade. Alone among the great industrial nations the United States has increased the flow of its industrial exports since the war. Already we are exporting nearly 10 per cent of our manufacturing and mining output, compared with about 13 per cent of the production of our farms. Unquestionably, moreover, the volume of our industrial exports is destined to increase yet more. Industry has acquired an export-surplus problem nearly as acute and difficult as that of agriculture. It is, therefore, less interested in the tariff than it formerly was. As a matter of fact, there is a large financial and industrial interest which already holds that American industry is outgrowing tariff protection.

It would be in the highest degree unwise for farmers at this time to launch an attack on the tariff without carefully considering the possibility that in the near future they may need it more than any other economic group in the country. I am strongly convinced that the relative advantage of tariff protection will swing definitely to the side of agriculture, as the dependence of our farmers on foreign markets grows less and that of our industrialists becomes greater.

Items of Interest

DEPARTMENT OF COMMERCE
WASHINGTON

Bureau of Mines Activities in Fiscal Year 1926

Continuation of the educational campaign designed to decrease the death and injury rates among the million miners of the United States was the predominant feature of the activities of the Federal Bureau of Mines during the fiscal year 1926, the first year in which the Bureau functioned under the Department of Commerce. Substantial progress was achieved in the movement for the rock-dusting of bituminous coal mines as a preventive of explosions, a great number of the larger mines having adopted this safety measure. A striking instance of the efficacy of rock-dusting was afforded in the explosion in the New Orient coal mine in southern Illinois in January, the employment of rock-dust localizing the explosion and holding the number of deaths to five at a time when approximately 1,000 men were at work in the mine.

Studies recently completed by engineers of the Pittsburgh experiment station have demonstrated that voice signals can be transmitted in and out of a mine, through more than 400 feet of strata, by the use of dry cells as a source of electrical energy and of modified telephone parts as receiving and sending apparatus. The development of practical means of communication between miners entombed after mine fires and explosions and rescue parties on the surface would naturally be of the greatest aid in the conduct of mine rescue operations.

A carbon monoxide recorder developed at the Pittsburgh station has given excellent service in a number of fields. This delicate instrument gives warning of the presence of this deadly gas in tunnel atmospheres of four parts in ten thousand parts of air, and indicates much lower concentrations. The recorder should prove of value in the maintenance of safe atmospheric conditions in the vehicular tunnels of the country now congested with automobile traffic.

The Bureau is conducting an intensive search for sources of helium, so vital in the operation of monster dirigibles of the Los Angeles type. A Government helium reserve has been established to include the Woodside, Utah, natural gas structure in which helium gas has been discovered. Experiments on the use of synthetic atmospheres, composed of helium and oxygen, in compressed-air work, conducted by the Bureau of Mines in cooperation with the Navy Department, and the U. S. Public Health Service, have demonstrated the value of these mixtures in increasing the efficiency of divers and decreasing the hazard to their health. If cheap helium can be made available, it is believed that the results of this research should greatly extend the whole range of submarine and compressed-air engineering.

Studies have been conducted looking toward the utilization of vast deposits of low-grade iron ores in Minnesota, Alabama and elsewhere. As an aid to this study, the Bureau operated at its Minneapolis station the only experimental blast furnace in the world capable of producing conditions encountered in the large commercial furnaces. Studies designed to liberate the United States from dependence on imported high-grade managnese ores and manganese alloys, essential in steel making, are in progress. The Bureau is studying the problem of increasing the recovery of oil from depleted sands, it being estimated that 80 per cent of the oil is left underground under present methods of production.

Technical Problems of Industry Solved by Government Scientists

That American industry is more and more turning to applied science to aid in solving its many and intricate technical problems is indicated in the annual report of George K. Burgess, Director of the Bureau of Standards, of The Department of Commerce.

The Bureau of Standards maintains contact with industry through approximately 80 advisory committees, and through a large number of "research associates" who are sent by industrial groups to work on problems of interest to their respective industries. Results are quickly applied by the industries concerned so that the public soon benefits from improved processes. During the fiscal year 1925-26 there were 62 of these associates at the bureau, representing 36 separate industries.

Nearly 180,000 tests having a fee value of $675,046 were completed by the bureau during the year. The character and scope of these tests spanned the province of applied science from sugar to cement, from thermometers and pyrometers to paints and varnishes, and from aerial photography to studies of city planning. In addition to the vast amount of consulting and specification work for various Government departments, specific research work covering 40 projects was performed for 15 Government establishments.

The work in the field of simplified practice was actively carried on. Forty-five simplified practice recommendations have been accepted by industries, resulting in great savings in the production of articles in common use. This is one of the most important ways in which an industry can effect immediate economies, and the demand for publications on this work is evidence of the interest manufacturers are showing in it.

The work on building and housing produced some important results. A standard building code, submitted for general adoption, was drawn up by a special committee. A report was issued on the important subject of city planning and zoning, containing a list of 436 municipalities which have adopted zoning ordinances.

Among the outstanding research undertakings of the bureau during the year was that in connection with increasing the wearing quality of our paper currency. By introducing certain changes in the manufacturing process, a paper was developed which it is believed will increase the life of bills by fully fifty per cent.

A blue glass was developed for protecting the eyes of furnace workers, which gives a good contrast between the appearance of the furnace walls, and the melt, and yet cuts out the dangerous ultraviolet radiation. The camera used in making maps from airplanes was improved by introducing a plate of glass between the lens and film which eliminates distortion of the picture and reduces, by one-half, the flying time required for this work.

In the radio field the bureau has continued its studies of ways for reducing interference between broadcasting stations. The piezo oscillator, which employs a quartz plate possessing a definite mechanical frequency of vibration, has been developed as a practical and successful device for holding transmitting stations exactly on their assigned wave lengths. Standard frequency signals have been transmitted from the bureau's station, and the station at Stanford University, California, which have proved very useful in standardizing radio apparatus all over the country. A special direction finder was developed and installed on Coast Guard patrol boats, which could easily be added to existing radio equipment.

Many important investigations were made of the strength of building materials, including a program of 30 tests, on brick walls in the 10 million-pound compression testing machine, and other tests on steel columns. Fire tests were made on many types of walls, of theater curtains, and of sheet metal garages.

In concluding his report, Dr. Burgess points out the important needs of the bureau during the current year. These include, adequate support for the test work, and an appropriation for a new power plant, authority for the construction of which was granted at the last session of Congress.

Standard Specification Steam

Steam which meets the specifications for standard quality will maintain engine and turbine water rates up to guarantee figure. This makes any investment needed to attain this quality extremely attractive to those interested in reducing operating and repair costs.

Not only in purchasing new boilers should these specifications be followed but also the existing boilers should be subjected to close scrutiny.

The most efficient use of feed water treatment with modern boilers and operating methods will not of itself produce standard specification steam. Clean and dry steam cannot be secured by even the most exact chemical control and the consequent continuous purchase of expensive chemicals.

Improvements in treating feed water, the use of evaporators, heaters or filters will not of themselves produce standard specification steam. These are all of value in eliminating scale in boiler tubes and reducing slugs of water but cannot alter the fundamental principles of entrainment.

To secure clean and dry steam it is necessary to go to the basic cause—entrainment. Remove all entrained boiler water and all entrained dust from the steam and the problem is solved—not only permanently solved, and at no cost for chemicals and labor, but large savings actually show up on the cost sheet.

It is possible to dry steam by passing it through a superheater, or superheating elements in the boiler, but that does not mean that it is clean. Unless the steam is clean before superheating it will be dry and dusty after superheating.

The use of steam that does not meet with standard specification is usually followed by increased maintenance due to erosion of turbine blades, clogged superheaters, scored cylinders, sticking non-return valves, etc., and in addition also by increased operating costs due to excessive steam and oil consumption.

For this reason nothing less than standard specification steam should be countenanced in the power plant where economy and low maintenance cost are desired.

Standard specification steam should not contain more than nine parts per million of total solids regardless of the concentration of the water in the boiler and must not show more than two-tenths of one percent of moisture when tested with a throttling calorimeter.

Chain Drive Automatic Adjustment

Wear produces lengthening of the chain. However, this wear or lengthening is such a slow process that its effects of the drive are easily controlled by one of several simple methods. Manual control has been employed, but automatic idlers on the slack run of the drive are the latest and most satisfactory development.

Automatic adjustment not only takes care of any elongation that develops in service, but it also insures longer chain life and sustained quiet operation; it saves the chain from the high inertia strains that are likely to be set up in case of lost motion between shafts, and exercises considerable influence as a vibration damper.

Such a device is shown in figure 1, consisting of an idler sprocket (A) mounted on an eccentric bearing (B), so that it can revolve freely. The eccentric bearing is mounted on a stationary shaft (G). The movement of this eccentric bearing is under control of the coilspring (H). As the chain becomes slack, the spring H causes the eccentric bushing B partially to revolve, causing the idler sprocket to move in a direction to take up the slack. Two spring-actuated plunger pieces D, acting as pawls, are in constant engagement with the ratchet plate E; so that when the eccentric bushing has revolved a distance equal to the pitch of the ratchet, the bushing is held against any backward movement. As further slackness occurs in the chain the operation is repeated, thus automatically maintaining the chain in proper tension, and assuring speed relation between the driving and driven shafts.

Chain drives with automatic idlers can be applied to all styles of metal-working machines operated by motors transmitting up to 25 horsepower, and in some cases even more.

In applying the automatic idler there are no changes required in the location of the driving and driven units. It is necessary only to provide a stub shaft for the idler, to suit the style of drive to be adopted.

As the average application of the chain drive provides a contact over a large portion of the sprocket with which it meshes, sometimes being more than half the circumference, it is good practice to encase the drive so it will operate in a bath of oil, thus producing greater durability.

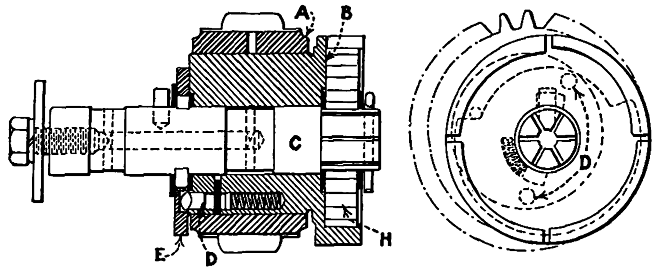

FIGURE 1. DETAILS OF AUTOMATIC IDLER AND VIBRATION DAMPER

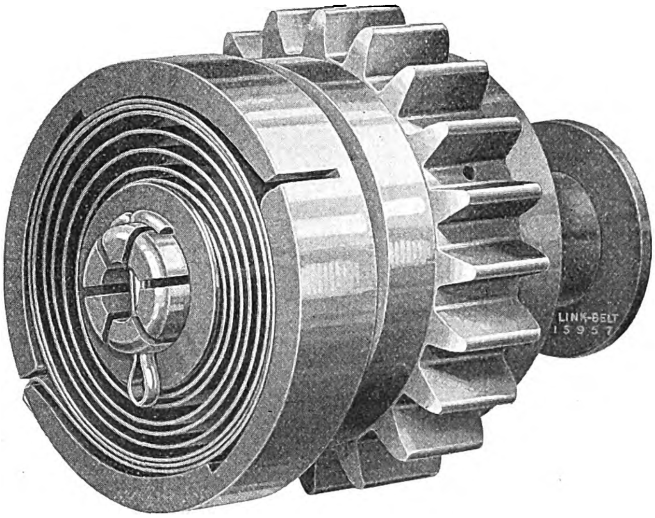

FIGURE 2. AUTOMATIC IDLER FOR MACHINE TOOL DRIVES

Comparisons of work (by means of microphotographs) on grinding machines using plain chain drive, and similar machines with the chain drive tension automatically maintained, showed that the finish produced by the latter type of drive was considerably better. The automatic adjustment brings to the machine tool the same refinement of operation that is brought to the automobile, where a similar use is made of silent chain.

Every user of machine tools should give as much consideration to the method of driving his machines as he does to the choice of machine itself.

ENGINEERS AND ENGINEERING will be glad to furnish full information, sketches, etc., to anyone interested in this subject.

Civil Aviation in the United States[*]

By ARCHIBALD BLACK

Consulting Air Transport Engineer, Garden City, N. Y.

CIVIL aviation in the United States may be said to have started with the establishment of the U. S. Air Mail Service by the Post Office Department in 1918. Actually, we had some civilian activities years before that time but it took the nature of exhibition flying and "joy-rides" rather than operation for transport or other business purposes. Hence it seems quite logical to date civil aviation in this country from the start of the first air mail route operating on a regular schedule. This experimental route ran between New York and Washington, D. C., but was discontinued some time after the inauguration of the transcontinental service. For several years after the close of the war, American civil aviation maintained its stand among that of other nations through the operations of this Air Mail Service and those of the aerial "Taxi" operators. We had only a couple of scheduled passenger services, a fact often seized upon by the misinformed in an effort to prove that the United States was hopelessly behind. This conception of our backwardness has not been borne out by the figures available.

Estimates of Operations Here

In the absence of Government regulation (now about to be put into effect) it has been necessary to depend upon private compilations of the mileage flown here. Many efforts have been made to estimate this mileage but they have carried the disadvantage of being unofficial and often of doubtful accuracy. Of the various compilations, those of the Aeronautical Chamber of Commerce have become regarded as the most authentic and probably err on the low side if at all. It is therefore interesting to note that these estimates added to the official mileage of the Air Mail Service have placed the United States well ahead of any European country for the past few years. Where we did lag behind was in the operation of privately-owned scheduled air routes—one branch of aviation only. Through the sudden expansion of the past twelve months our position in this regard has been immeasurably improved. Most of the new operating companies have not yet completed a full year but it is possible to estimate their annual mileage in advance, basing this upon their mail schedules and making due allowance for interruption through weather or other cause.

European Nations Behind Us in Aviation

In the accompanying Table the foregoing estimates are presented in detail together with general data on the various operators. Fig. 1, is a map of the United States showing the location of the routes given in the Table and illustrating the manner in which the country is covered. It should be clearly understood that the table and map include none of the "air taxi" or non-scheduled services of which more will be said later. The total of the estimates, given at the bottom of the table, is very significant when compared with European operations. By taking the latest available figures for European activities and making due allowance for normal expansion it becomes possible to project these into next year for comparison with our existing operations. In Fig. 2, this information is presented graphically, only the leading nations being included. German figures have been omitted intentionally because of the recent reorganization and some consequent uncertainty about the mileage to be covered under the new plans. The German mileage will probably run between the British and French. It is very evident from this comparison that the much-vaunted European air transport is now far behind that of the United States. If any one individual is to be singled out as responsible for the tremendous jump in American air transport, that man would be Henry Ford. Yet this credit would have been earned not so much by his actual work—which has been constructive in itself—as by the mere fact of his appearance in aviation. This was interpreted by the general public as indicative of the commercial value of air transport.

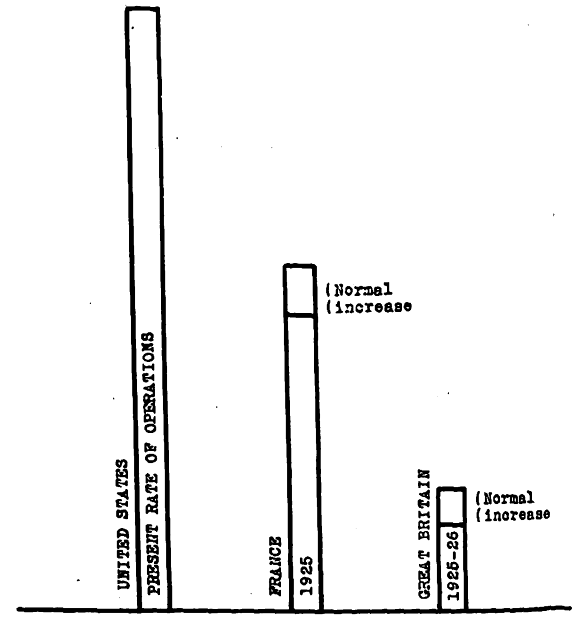

FIGURE 2. ANNUAL MILEAGE OF AIR TRANSPORT SERVICE AS INDICATED FOR YEAR 1926-27

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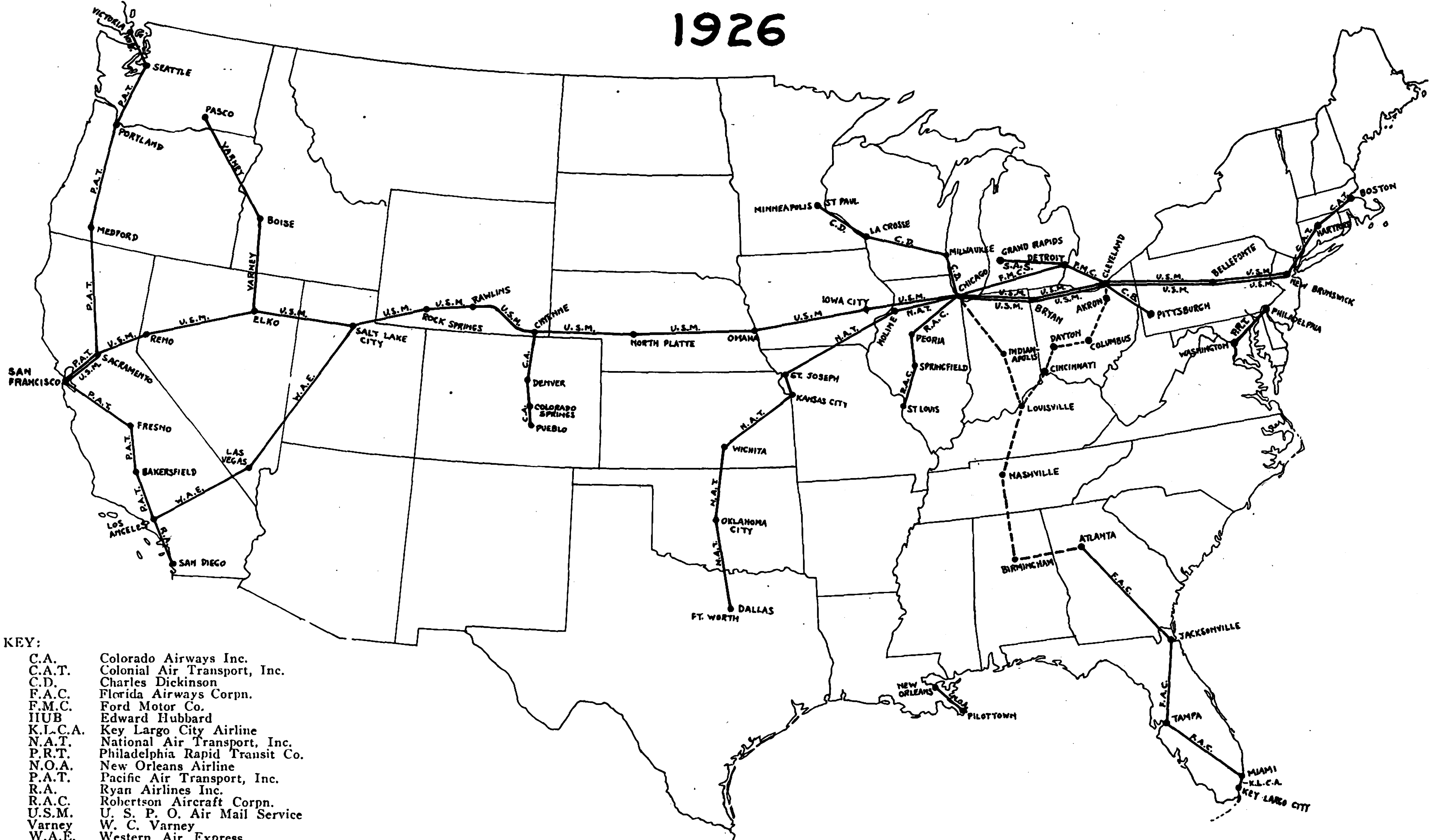
[*] Address presented before a joint meeting of the American Society of Mechanical Engineers' Aero Club of Pennsylvania and the Engineers Club of Philadelphia, September 7, 1926.

SCHEDULED AIR TRANSPORT SERVICES IN THE U.S.A.
1926


VICTORIA
SEATTLE
P.A.T.
PORTLAND
PASCO
VARNEY
BOISE
MEDFORD
ELKO
U.S.M.
RENO
SACRAMENTO
SAN FRANCISCO
FRESNO
BAKERSFIELD
LOS ANGELES
R.A.
SAN DIEGO
W.A.E.
LAS VEGAS
SALT LAKE CITY
ROCK SPRINGS
RAWLINS
CHEYENNE
C.A.
DENVER
COLORADO SPRINGS
PUEBLO
NORTH PLATTE
OMAHA
ST. JOSEPH
KANSAS CITY
N.A.T.
WICHITA
OKLAHOMA CITY
DALLAS
FT. WORTH
MINNEAPOLIS
ST PAUL
C.D.
LA CROSSE
MILWAUKEE
CHICAGO
IOWA CITY
MOLINE
R.A.C.
PEORIA
SPRINGFIELD
ST LOUIS
GRAND RAPIDS
S.A.S.
F.M.C.
DETROIT
CLEVELAND
C.B.
BRYAN
AKRON
PITTSBURGH
DAYTON
COLUMBUS
INDIANAPOLIS
CINCINNATI
LOUISVILLE
NASHVILLE
BIRMINGHAM
ATLANTA
F.A.C.
JACKSONVILLE
TAMPA
MIAMI
K.L.C.A.
KEY LARGO CITY
NEW ORLEANS
N.O.A.
PILOTTOWN
BELLEFONTE
NEW BRUNSWICK
PHILADELPHIA
P.R.T.
WASHINGTON
HARTFORD
C.A.T.
BOSTON

KEY:

C.A.	Colorado Airways Inc.
C.A.T.	Colonial Air Transport, Inc.
C.D.	Charles Dickinson
F.A.C.	Florida Airways Corpn.
F.M.C.	Ford Motor Co.
HUB	Edward Hubbard
K.L.C.A.	Key Largo City Airline
N.A.T.	National Air Transport, Inc.
P.R.T.	Philadelphia Rapid Transit Co.
N.O.A.	New Orleans Airline
P.A.T.	Pacific Air Transport, Inc.
R.A.	Ryan Airlines Inc.
R.A.C.	Robertson Aircraft Corpn.
U.S.M.	U. S. P. O. Air Mail Service
Varney	W. C. Varney
W.A.E.	Western Air Express
C.B.	Clifford Ball
S.A.S.	Stout Air Services Inc.

——Solid Lines Indicate Routes Now Operating or, Contracted for and now equipping for operation.

═══ Double Lines Indicate Two Independent Services.

- - - Routes for which the U. S. Post Office has asked bids.

MAP COMPILED BY ARCHIBALD BLACK

SCHEDULED AIR TRANSPORT OPERATORS IN THE UNITED STATES

(Copyright, 1926, by Archibald Black)

NAME	C. A. M. No.	ROUTE	1-WAY MILES	ANNUAL MILEAGE	STARTED
Colonial Air Transport Inc.	1	Boston-Hartford-New York	225	135,000	July 1, 1926
Robertson Aircraft Corpn.	2	Chicago-Springfield-Peoria-St. Louis	278	156,000	April 15, 1926
National Air Transport Inc.	3	Chicago-Moline St. Joseph-Kansas City-Wichita-Oklahoma City-Ft. Worth and Dallas	1,000	736,000	May 12, 1926
Western Air Express Inc.	4	Salt Lake City-Las Vegas-Los Angeles	650	455,000	April 17, 1926
W. T. Varney	5	Elko-Boise-Pasco	435	130,500	April 6, 1926
Ford Motor Co.	6	Detroit-Cleveland	91	54,353	April 13, 1925
Ford Motor Co.	7	Detroit-Chicago	237	161,925	June 1, 1926
Pacific Air Transport Inc.	8	Seattle-Portland-Medford-Sacramento-San Francisco-Fresno-Bakersfield-LosAngeles	1,121	672,600	September 1, 1926
Chas. Dickinson	9	Chicago-Milwaukee-LaCrosse-St. Paul-Minneapolis	377	263,900	June 7, 1926
Florida Airways Corpn.	10	Atlanta-Jacksonville-Tampa-Ft. Meyers-Miami	683	409,800	April 1, 1926
Clifford Ball	11	Cleveland-Pittsburg	120	72,000	
Colorado Airways Inc.	12	Cheyenne-Denver-Colorado Springs-Pueblo	199	119,400	May 31, 1926
Philadelphia Rapid Transit Air Service Inc.	13	Philadelphia-Washington	120	168,000	July 16, 1926
Stout Air Service Inc.		Detroit-Grand Rapids	142	85,200	July 31, 1926
Ryan Airline Inc.		Los Angeles-San Diego	120	119,225	March 1, 1925
New Orleans Airline	Foreign Mail	New Orleans-Pilottown	80	23,000	April 9, 1923
Edward Hubbard	Foreign Mail	Seattle-Victoria (B. C.)	84	20,000	Oct. 15, 1920
U. S. Air Mail Service	U. S. M.	New York-(New Br.) Cleveland-Chicago	726	363,000	July 1, 1925
U. S. Air Mail Service	U. S. M.	New York-Cleveland-Chicago-Omaha-Cheyenne-Salt Lake City-Elko-San Francisco (etc.)	2,669	1,782,400	Sept. 8, 1920 (last leg)
Key Largo City Airline		Miami-Key Largo City	50	8,200	Dec. 15, 1925
Robt. S. Fogg	R. F. D.	Around Lake Winnipesaukee (R. F. D. Route)	43	10,350	Aug. 1, 1925
		TOTALS	9,450	5,945,853	

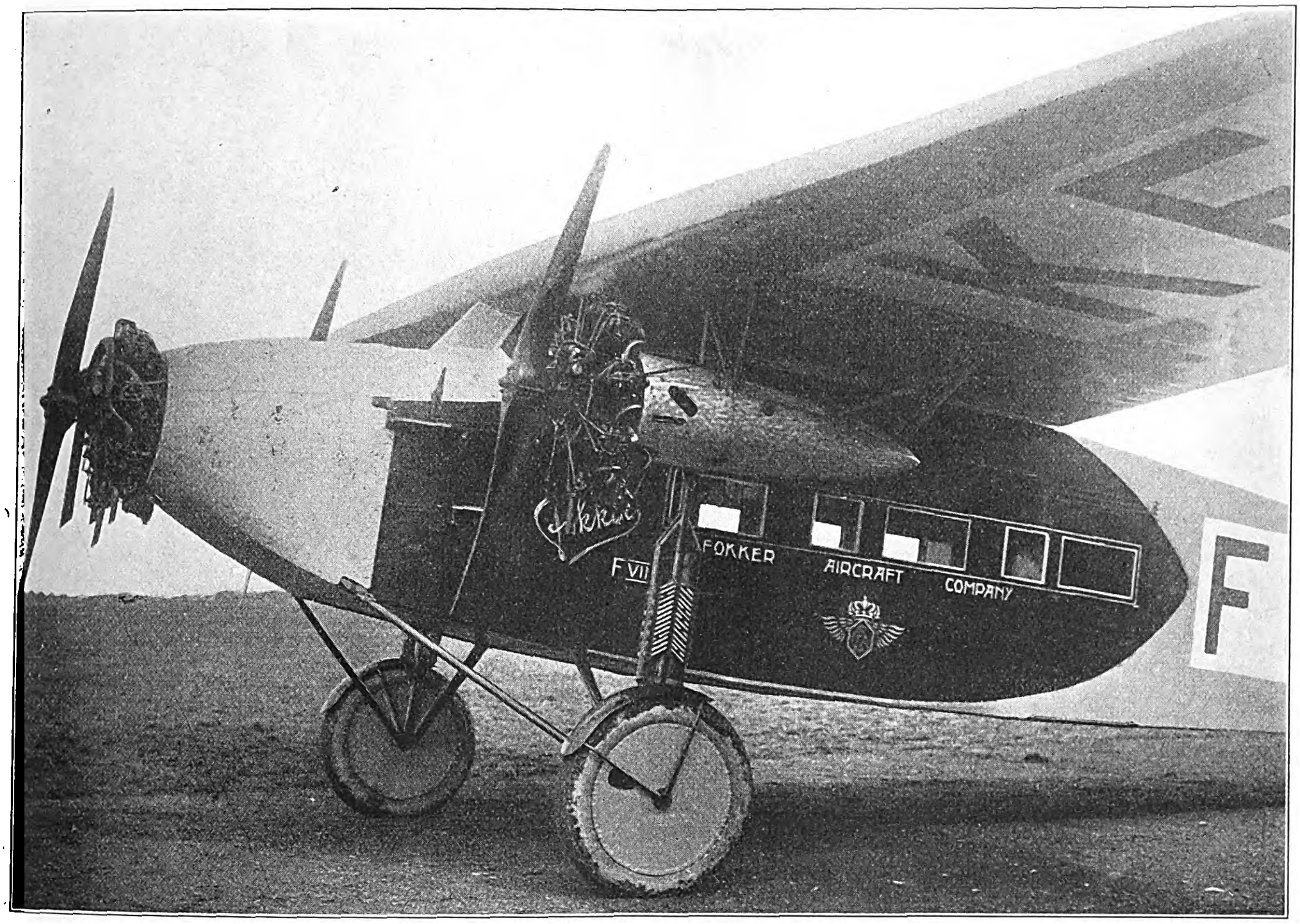


FIGURE 3. FOKKER TEN PASSENGER AIR LINER POWERED WITH THREE WRIGHT 700 H.P. ENGINES ©*Blyburn Photos*

Ford Activities

For several years the Fords had been interested in aviation but this knowledge was confined to a group in the aircraft industry and did not reach the public until last year. Early in 1925 the Ford Motor Company began operation of its Detroit-Cleveland and then its Detroit-Chicago air routes. For the first time the general public suddenly awoke to the Ford interest in aviation. In themselves these operations were of almost secondary importance but the magic of the name "Ford" carries unusual weight. The widest of publicity was given to the plans and the public suddenly began to show appreciation of the possibilities of the air plane. Men who had been developing air transport plans for a few years seized upon this opportunity to carry them through to completion, riding on the crest of a wave of favorable sentiment. Several announcements of important air transport plans followed each other in rapid succession. The Ford activities served to furnish the first little snowball that grew to the proportions of an avalanche as it went on, sweeping all opposition before it. The timely passage of a Federal Law authorizing the Postmaster General to contract for carrying of domestic mail by air also greatly aided this development. Within the past several months these new firms have been putting their plans into operation. The first of the new routes under the air mail contracts went into operation when the Florida Airways Corporation started running on April 1, 1926. At the time of writing all but two of the routes shown on the map are in actual operation and the others will follow during the next week or two.

Types of Engines Being Used

It is pleasing to be able to record that all of the equipment in use on our airways is of domestic construction. The 400-horsepower Liberty engine—which was so severely criticized during the war—has more than vindicated itself. It has also proven more versatile than, perhaps, its designers anticipated—having been the standard power plant of most of the larger commercial airplanes to date. Of course, as might be expected, present indications now point to its early displacement by some of the more recent types. Among the smaller airplanes, such as have been used for "aerial taxi" services, the 90-horsepower Curtis OX engine has been used almost universally until recently. It was with this engine that most of the non-scheduled operators built up their reputations. Gradually the newer and post-war types of engines are coming into use and such models as the Wright "Whirlwind" and the later

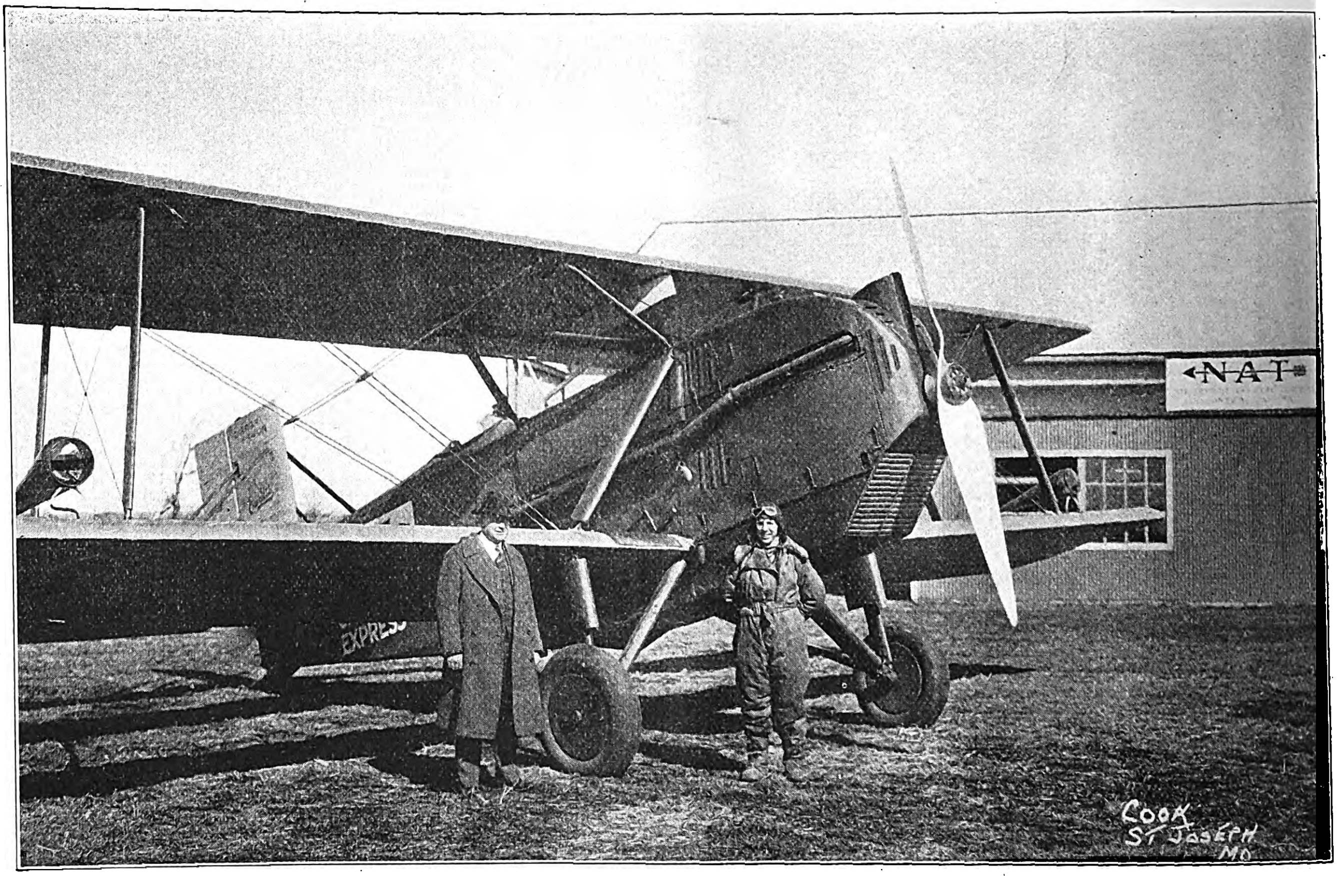


FIGURE 4. LANDING FIELD AT ST. JOSEPH SHOWING THE N. A. T. HANGAR AND THE "CARRIER PIGEON." © *Blyburn Photos*

Curtis, Packards, and others are finding their way into service. Recently there has been a marked drift towards the air cooled type, at least in the sizes less than 500-horsepower. While the choice of engines has in the past been influenced largely by the availability of war surplus material, popularity of the newer models is increasing. It is significant and worthy of mention that no foreign engine has been able to hold its own against the domestic product in the hands of civil operators.

Types of Airplanes Used

The first civil operations after the War were started with war-surplus Navy flying boats, Army DH-4s and Curtiss JN-4 airplanes. The first-mentioned were used in the early operations of Aeromarine Airways, the second by the U. S. Air Mail Service and the last were used largely by the operators of "aerial taxi" services. It should, of course, be noted that radical alterations were usually made in order to convert these types to civil use. Gradually the war-surplus types have been replaced by more recent and better suited designs and in a short time they will have completely disappeared. Present operations are being carried on with such later types as the Douglas Transport; American Fokker; Curtiss "Lark," and "Carrier Pigeon"; Waco; Swallow; Buhl-Verville; Martin; Loening; Elias; Sikorsky and others. Every one of these represents modern development and each has been designed for some specific use. As the field of civil aviation grew, distinctions between the various applications became clearer and these distinctions became reflected in the design of the later airplanes. No operator would today think of purchasing an airplane without first determining which make and model was best suited to his purpose. And the make which is best suited for one purpose is frequently a complete misfit if applied to some other use. The various manufacturers have come to appreciate this and many of them now confine their productive efforts to satisfying only one class of service. This condition is somewhat analogous to the manufacture of passenger cars, trucks and busses in the automobile field, or coaches, freight cars, Pullman cars and locomotives in the railroad field.

Airways Lighting Development

In the development of airways we have made remarkable progress in the United States. The Air Service has been steadily surveying air routes and making the information available to the civilian flyer, while the Navy has been similarly recording and publishing information on flying facilities along the coast lines. Under the able direction of Colonel Paul Henderson (now General Manager of National Air Transport, Inc.), the Air Mail Service a few years ago took up the problem of developing night flying equipment for civil purposes. The interest of several manufacturers of light-

FIGURE 5. LOADING THE FIRST MAIL CARRIED BY THE FLORIDA AIRWAYS CORPORATION

ing equipment was enlisted and many experiments carried out. These resulted in a decision to operate by night over part of the transcontinental route and the lighting of this airway was carried out from Chicago west to about Cheyenne. Once the practicability of night operation on schedule had been demonstrated, Colonel Henderson proceeded to arrange for lighting of the route between New York and Chicago. This work was completed and overnight service between these cities was started on July 1, 1925. The whole aviation industry owes a debt of gratitude to Colonel Henderson for his work in pushing the development of lighting equipment for these routes. In addition to facilitating extension of air transport in this country, the lighting of these airways spurred American manufacturers to the development of equipment that is now accepted as a standard for the rest of the world. Thus the conditions existing just a few years ago have been completely reversed.

Performance on the New Routes

In the matter of performance the new air mail and other operators have made an excellent showing. Florida Airways Corporation, flying over a route previously uncharted, maintained an operating efficiency of 97% to date. Western Air Express flying 1,300 miles daily, has been running from April 17 to the date of writing without even a forced landing. The Ford Motor Company has been running for several weeks without interruption of schedule making three round trips daily with only two airplanes, the reserve craft having remained idle meanwhile. Robertson Aircraft Corporation made 219 single trips out of a possible 220, the one missed being caused by a severe storm forcing a landing and in this case the mail was forwarded the remaining few miles by rail. W. T. Varney's pilots flew about 75,000 miles with only one forced landing. National Air Transport, operating about 2,000 miles daily through a portion of the area subject to cyclonic storms, showed an average of 97% arrivals on time for its first three months. Losses of airplanes through accidental damages have been extremely rare.

Aerial "Taxi" Operations

In parallel with the developments of organized and scheduled transports but somewhat ahead of it, an important business has been created in this country in the hire of airplanes. This branch of aviation has never been given a thoroughly satisfactory name. Sometimes it is referred to as "aerial service" and at other times as the "aerial taxi" business. After the close of the War it was started through the desire of the public to experience the novelty of an airplane ride. As the novelty wore off, other uses began to appear for the service and it gradually shifted from the basis of "Joy-riders" to the more stable one of rendering a special class of transportation to those requiring it. The estimates of the Aeronautical Chamber of Commerce for 1925 show that some 290 operators are engaged in this service. Deducting the distance flown by some of these in scheduled service but including mileage flown in aerial photographing and cotton dusting, the remaining distance totals some 5,007,819 airplane miles in 1925. In the nearest corresponding period British operators in the same class flew only 139,000 airplane miles.

Photography, Cotton-Dusting and Advertising

One of the divisions of aviation, which has been developed on a thoroughly substantial basis, is that of aerial photography and aerial surveying. Starting as somewhat of a by-product of aviation, this business has developed into one of its most important branches. Aerial maps and photographs have become accepted in the general business world as filling an extremely useful purpose. Originally conceived for military use during the War, the aerial map has since come into its own. Few cities today find it practicable to get along without an aerial map; railroads and power companies make an aerial survey the basis of their first right-of-way studies; manufacturing firms use the oblique aerial photographs to show the extent of their plants and real estate operators make use of this type of aerial photograph in their sales work. Fairchild Aerial Surveys, Hamilton Maxwell, Inc., and others have been largely responsible for this development.

Insecticide spraying from airplanes was first tried experimentally a few years ago by U. S. Air Service in conjunction with the Department of Agriculture. Since then this work has been taken up by private capital and the spraying of cotton fields has been developed upon a business basis by such firms as the Huff-Daland Dusters, Inc. Efforts are now being made by this firm to extend the method to other branches of agriculture.

Aerial advertising is still another phase of aviation which is being developed and this may, in future, become of considerably more importance than it is now. As yet its possibilities seem to have only been scratched, the most successful application being "sky-writing." In this system advertisements are written in the sky by means of smoke discharge from an airplane. The system was started by an English firm and is being exploited here by its associated company.

On the whole, civil aviation in the United States has little to be ashamed of and much to be proud of. In a world of subsidies it has much more than held its own and with but little artificial stimulus. Indeed, the **only** artificial stimulus has been the operation of the Government Air Mail Service. For several years past, American aviation has maintained its mileage with that of any other nation—foreign propaganda notwithstanding! With this year's tremendous increase in our scheduled services, our mileage will rise to a point where no amount of propaganda can hide the facts that the United States leads the world in aviation.

Patent vs. Copyright Law for Industrial Designs

By JOHN DASHIELL MYERS,

Of the Philadelphia Bar

EVERY manufacturer and dealer whose products involve industrial designs, no matter how simple they may be, has a vital interest in legislation now pending in Congress which not only threatens the development of industrial art, but may seriously embarrass industry generally.

The substitution of copyright for patent protection for designs, and the repeal of the design patent laws, is the basic change embodied in this legislation, which is officially known as H. R. Bills 6249 and 13117. The change sounds simple enough but, owing to the fundamental differences between copyrights and patents, its effects are far-reaching.

The degree of protection afforded against infringement, for instance, will be much less than under the present patent laws. On the other hand, manufacturers, dealers, and the public generally will be confronted with the prospect of endless litigation under copyrights indiscriminately registered for designs which are not now entitled to protection at all, such as those lacking novelty or having merely a trivial character.

As to the degree of protection, it should be noted that a patent grants an absolute, unqualified monopoly in the subject-matter patented, but a copyright confers merely a limited or qualified monopoly in the copyrighted work. In other words, a designer obtains under a patent an absolute exclusive right **in the design itself,** while under a copyright he will obtain merely the right to prevent others from **copying his original work** in producing the design.

There are correspondingly different tests for infringement. Under a copyright it would rest in the finding that the design complained of is not an original treatment by the defendant, but is a copy, more or less servile, of the plaintiff's copyrighted design. Such a test is more favorable to the defendant than the test of infringement of a design patent, which is based solely on substantial resemblance between the two designs, regardless of whether the defendant's design was copied from plaintiff's, or subsequently produced independently.

Applying this difference specifically, if a manufacturer developed at much expense a distinctive and very valuable industrial design and obtained a copyright registration for it, he would not be able to protect his design against anyone else who later, independently and without copying, produced a design identical with his work. Such a manufacturer would have to share his market with the producers of the later design. The distinctive character of his goods would thus be lost, and the reward to which he was justly entitled as the one making the real contribution to the "progress of science and useful arts" would be largely snatched away.

Under these circumstances, there will naturally be little inducement to manfacturers to spend large sums developing distinctive articles only to have their designs duplicated later by competitors who would share in their commercial possibilities.

In connection with this proposed legislation it should also be noted that there are fundamentally different standards determining the right to protection by patent and by copyright, and different methods by which they are secured.

To be patentable, a design must be new, show sufficient ingenuity to amount to an invention, be applied for by the first inventor, and meet certain other conditions specified in the patent laws. Oath as to the statutory requirements must be made by the inventor. The Patent Office examines the application and issues the patent only after search through prior patents.

The chief requisite of copyright ability is originality. This does not mean absolute originality—in the sense in which the term is popularly used—but mere originality with the author producing the work, so that it embodies the result of independent effort on his part. Even the extent of the originality may be modest. The work need not be new, nor is the first to produce it the only one entitled to a copyright.

Applications claiming copyrights are registered in the Copyright Office as a matter of routine. No sworn statement must be furnished by the author as to the originality of the work. There is no examination or search, as the Copyright Office is not required to pass on the applicant's right to a monopoly.

In view of these differences, another far-reaching effect of this proposed change will be that "the bars will be let down," permitting copyrights on many designs not meeting the requirements for a patent, such as those which are of trivial character and involve merely the skill of an ordinary workman, and those which are now the property of any manufacturer who desires to use them.

Registration will follow automatically for practically all designs for which applications are filed. All questions as to the originality of the designs registered and the validity of the copyrights based on such registrations will be left for determination by the courts when suits for infringement are subsequently brought.

Freed from examination and weeding out of design applications under the patent laws, and with no examination whatever in connection with the more liberal requirements of copyright law, an avalanche of monopolies will spring up over night for designs not now entitled to protection at all. These copyright registrations will present a wide opportunity for harassing tactics and will breed much litigation.

A concern marketing an article of a particular design which had been common property for many years would be open to attack at any time under a copyright registration which could be readily obtained by another for an identical, or substantially identical, design. Under these circumstances, there would be no infringement, if the design so marketed had not been copied from the copyrighted work. But even if this satisfactorily appeared from the evidence and the concern should win, the trouble and expense of the litigation might make it an actual loser.

The fact that the copyrighted design lacked novelty and was identical with prior designs in the public domain would be no defense to such an attack, and the concern would be liable nevertheless as an infringer if the design of the article it was selling had been copied from the copyrighted design.

Confusion of rights and consequent law suits will also grow out of the fact that the proposed change will make it possible for different persons to secure separate copyright registrations on identical designs. This would manifestly be a great hardship upon the one first producing such a design and copyrighting it. He and his trade might be confronted at any time with wide spread competition developed under a later copyright. The commercial value of his rights would be reduced by each later copyright, while the possibility of such later copyrights being obtained would be increased in proportion to the commercial value of the design.

The situation would be menacing enough in instances where the design of the later copyright was produced by independent work and without copying, but how much worse it would be if this was not true. Yet as copyrights are registered as a matter of routine, the door will be open for the unscrupulous to readily cloak themselves with copyright registration, and the way of the pirate will be made easy.

One of the principal objects of the proposed change is to avoid the delay involved by examination in securing design patents. It is claimed that designs, if promptly marketed, may be copied by competitors, cheapened, and their value destroyed before patent rights can be obtained under which suit can be brought.

The need, if any, does not justify the radical departure proposed. The difficulty, if it exists, is not general, but applies only to particular cases. Doubtless relief could be obtained by appropriate changes in the present laws, or their administration, but even now patents are promptly granted on designs which are not open to objection.

Creators of designs which meet the requirements of the patent laws will scarcely be willing to accept a monopoly of less value, in order to avoid the short delay involved in examination. Of course, those whose designs do not meet these requirements may be in favor of the proposed change; not, however, because of merely avoiding short delay, but because now they are not entitled to any kind of a monopoly at all. This, after all, is the real purpose back of the proposed change in the law.

But, as a matter of fact, it is against the public interest to confer a monopoly on **all** designs; many should be protected, if at all, only under the law of unfair competition. When one produces a design which, as applied to a particular article of manufacture, may be "as old as the hills," or may already be the subject-matter of a copyright to another who was the first to produce it and give it to the public, he has scarcely made any very useful contribution to mankind, or given sufficient consideration for a monopoly, through the mere fact that he claims it was original **with him** and is his own independent work.

The change would place a premium on ignorance, and the less a designer knew of the progress and development in the particular art in which he was working, the better off he would be.

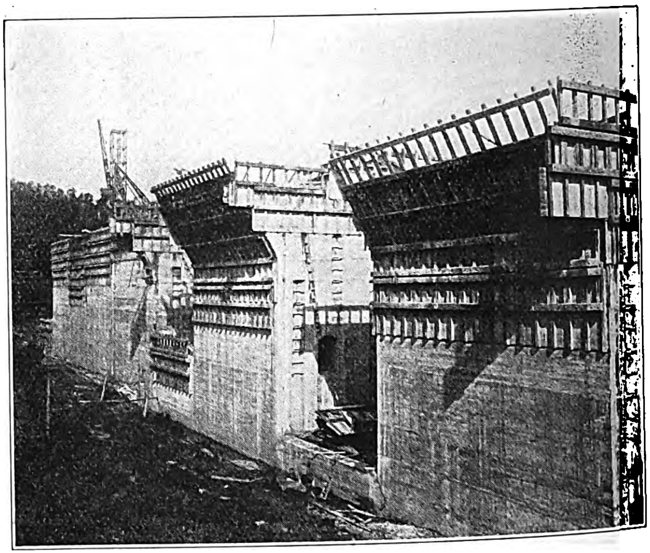
The sum and substance of the matter is that copyright is not an appropriate form of protection for industrial designs, because it has been developed to deal with literature and the fine arts. Industrial designs, on account of their relation to the useful arts, involve conditions of a different kind which are more analogous to those under patents than under copyrights.

The proposed legislation recognizes this, for while purporting to substitute copyright for patent protection, it fails to conform to the established basis of copyright law. Instead it is a strange mixture of copyright and patent law provisions which are inconsistent and difficult to reconcile, and the true meaning of which, in their new relation, is indefinite and could only be determined after years of construction by the courts.

The effect of the change will not be to encourage the production of industrial designs. It is distinctly a step backward, and against the public interest and should receive vigorous opposition.

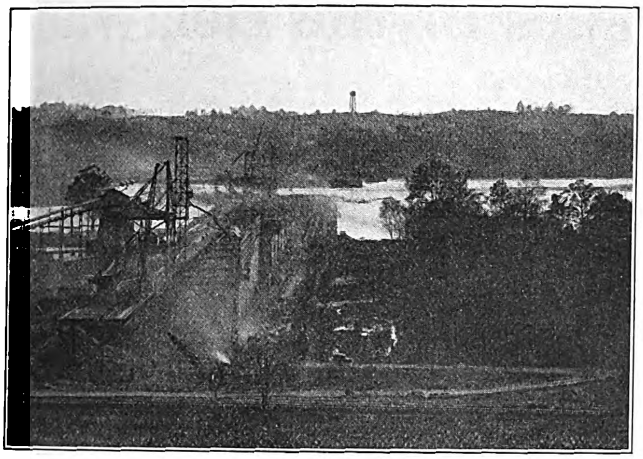
Progress at Conowingo During the Summer Season of 1926

WORK on the gigantic hydro-electric development at Conowingo on the Susquehanna River has now been in progress for over eight months—since March 8, 1926, to be exact. This is the plant by means of which the Philadelphia Electric Company will obtain electrical energy to supplement its steam-generated supply in and near Philadelphia. A description of the ultimate development appeared in the July issue of this periodical.


Up-Stream Face of Eastern Section of Dam Looking Toward Shore. Cut Illustrates Method of Construction of Alternate Sections and Shows Inspection Tunnel, Vertical Drains and Provision for Keying the Joints (10/6/26)

After commencing operation last spring the forces at work were rapidly built up to several thousand men, the greatest number employed at one time being slightly under 4,000. At first it was necessary to build construction roads, bunk houses and messhalls to accommodate the large number who do not live in the vicinity, offices, storehouses, work shops and a 33,000 volt transmission line nearly ten miles long to supply construction power and light, all of these being of a temporary nature. Other work of a more permanent character includes many items in addition to those which are usually thought as comprising such an enterprise, i. e., the dam, the power house, and the transmission line from the power house to the point of utilization. Such items are: the construction of a railroad "spur" nine miles long from Havre de Grace to the power house on the west side of the river to serve both as a construction road and for permanent use in transporting supplies; the relocation of the Columbia & Port Deposit Branch of the Pennsylvania Railroad, this being necessitated by the present location being below the future pond level; the erection of a bridge on top of the dam to replace the present antiquated structure which will be much below the future water level; the relocation of the main highway (Baltimore Pike) so as to make use of this bridge; and the construction of a permanent village to house the force of men who will operate the completed station. Some of these items, such as the railroad to Havre de Grace and the transmission line from Delta, Pa., are completed and in constant use; others are well under way; for example, a large part of the highway construction is complete and extensive grading for the new railroad location is in progress.

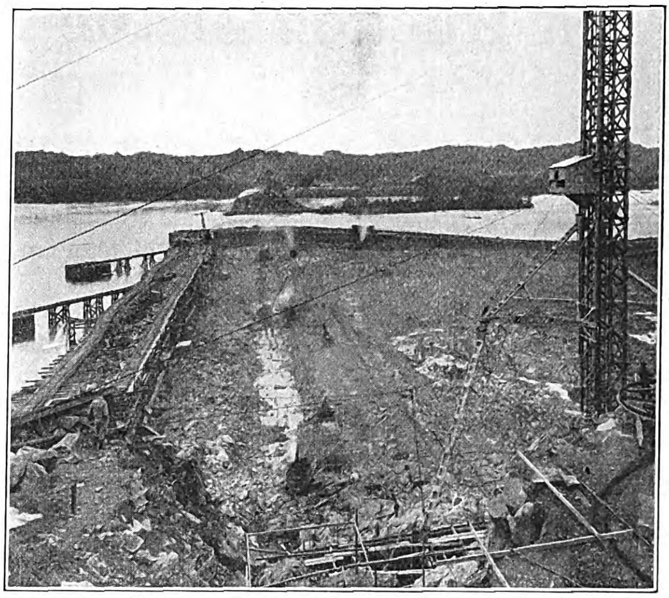
The question is often asked "How will the construction be carried out so as to allow the river to flow during the construction period?" During the present or 1926 stage of construction about one-quarter of the width of the river is left undisturbed. Two cofferdams have been built out from the shores within which the permanent construction is being carried out. The cofferdam on the west side encloses the site of the power house and its associated section of the dam including the west abutment and a part of the tailrace. The cofferdam on the east side ex-



General View of Project From East Side of River. Eastern End of Dam is Shown in the Foreground With the Operations at the Power House Site in the Distance (11/3/26)

tends out to about the middle of the river. Within this cofferdam, the permanent dam is being built with alternate sections completed only to the extent of the excavation and a fairly high footing course. The other sections will be carried to their complete height during this stage of construction. When this construction reaches a level above any expected high water, stop logs in the cofferdam will be removed, allowing a free flow of water through the gaps in the dam. The next step (to be started in the spring of 1927) will be to build a cofferdam between the two present cofferdams within which the permanent structure will be extended in alternate sections as in the first step, so as to join the power house section. The completed sections of the dam will include the supports for the highway bridge, so that the bridge can be completed before the notches are closed. It is expected to be open to traffic about the end of 1927. The third step will consist of opening the west cofferdam so as to allow the water to flow through the water passages which will later supply the turbines. Water tight forms can then be built across the notches in the east and center portions of the dam and then filled with concrete.

The construction is complicated by the very irregular flow conditions of the Susquehanna River. While high water may be expected during the winter and spring, it may occur, judging from past history, at any time in the year. Provision must, therefore, be made for protecting the work from high water at all stages of the work.



View From West Abutment Showing Excavation For Power House Site With Operations on the East Side of the River in the Back Ground (10/26/26)

Taken as a whole the project is nearly 25% complete. The west abutment has been completed and the excavation for the power house which involves removing a large amount of rock is nearly so, with some of the concrete in place. Considerable excavation has been done on the tailrace. On the east side, the excavation within the present cofferdam is complete including the shore section as far as the present tracks of the C. & P. D. Branch of the P. R. R., and the abutment section east of the tracks is now being excavated. Concrete is being rapidly placed for the dam, the footings being complete within the cofferdam and considerable progress has been made on those alternate sections of the dam which will be built to their full height during the first stage, as previously described, with some sections nearly up to the height of the spillway. The railroad relocation is progressing rapidly and several small bridges necessary to carry the railroad over the creeks which flow into the river are under construction. The highway relocation has been carried out well toward completion, and the clearing of the future pond is about one-third completed.

It is expected that the first unit will be in operation in the summer of 1928, and that the last of the seven units of the initial development will be available by the end of that year.

C. W. B.

Construction of the Cables of the Delaware River Bridge*

By H. D. ROBINSON

Consulting Engineer, Delaware River Bridge Joint Commission

THERE are three different methods of building suspension-bridge cables composed of high-tension steel wire, as follows:

First, the construction of cables composed of numerous wire ropes or wire-rope strands, laid parallel with one another, and bound or clamped together into a group forming a cable.

Second, the construction of cables made of parallel wires laid straight, side by side, by first laying the wires in groups of a given number of wires each, banded together into a solid cylindrical member known as a strand, along the shore or some other convenient place and then hoisting these strands to their correct place in the cables.

Third, the construction of cables made of parallel wires, by the "spinning-in-the-air process," the process whereby the wires are laid in the cables in their final position in the completed bridge, so to speak. This is the method on which I have been assigned to speak and which was used in the construction of the Delaware River Bridge cables and in all important suspension-bridge cables composed of wires laid straight and parallel since the adoption of this method by its inventor, the late distinguished engineer, John A. Roebling.

Balancing of the Strands

As it was the wish of Mr. Ralph Modjeski, Chief Engineer of the Board of Engineers, to let the strands of cable produce the resultant bending of main towers shoreward, due to the inequality of horizontal forces as the strands were laid in the saddles, every possible way was considered and investigated for accomplishing the desired end. The unbalanced forces between land- and main-span cables at the main-tower saddles were not so great but that the frictional resistance in the saddles would hold the individual strands, but there were other very important details of the construction to be considered, viz., the strands of the cables during their spinning.

It has been the custom on all recent suspension-bridge wire-cable constructions, and it is desirable, to have the temporary foot-bridges laid parallel to and just below the main cables with sufficient clearance for the operation of the cable-squeezers and wrapping-machines. This was the plan adopted at Delaware River. But the strands being constructed alongside the main cables are supported in sheaves over the main-tower and anchor-bent saddles, which sheaves are free to turn on their trunnions, thus allowing the strands to hang in their balanced position with equal catenary parameters in the spans corresponding to equality of strand stress and consequent balance in supporting sheaves at main saddles. This balanced position of strands decreased the sag so much in the main span and increased it so in the land spans, for every possible position of supporting sheaves and position of strand-shoe on the "leg" at anchorages, that it was found impossible to rely upon the individual strands to bend the towers; the use of "pullback" ropes was therefore recommended and the

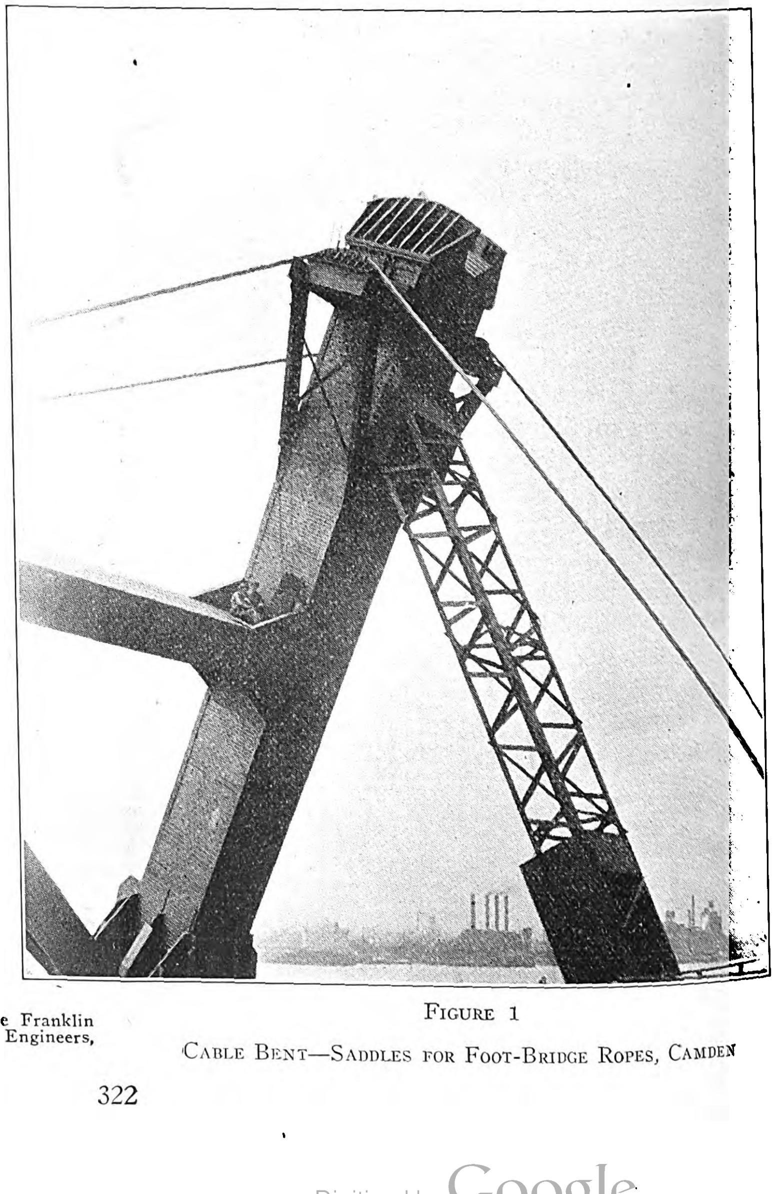


FIGURE 1

CABLE BENT—SADDLES FOR FOOT-BRIDGE ROPES, CAMDEN approval of their use was given by the Board of Engineers.

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*Extracts from a paper presented at a joint meeting of The Franklin Institute and the Philadelphia Section, American Society of Civil Engineers, Thursday, March 4, 1926.

The Temporary Foot-Bridges

The temporary foot-bridges for this work were similar to those used in the construction of the Manhattan and the Bear Mountain Bridge cables, and consisted of a timber walk 10 feet wide supported by two cables for each walk, each cable composed of three 2¼-inch-diameter galvanized steel ropes which were later to be used as suspenders for the main bridge superstructure.

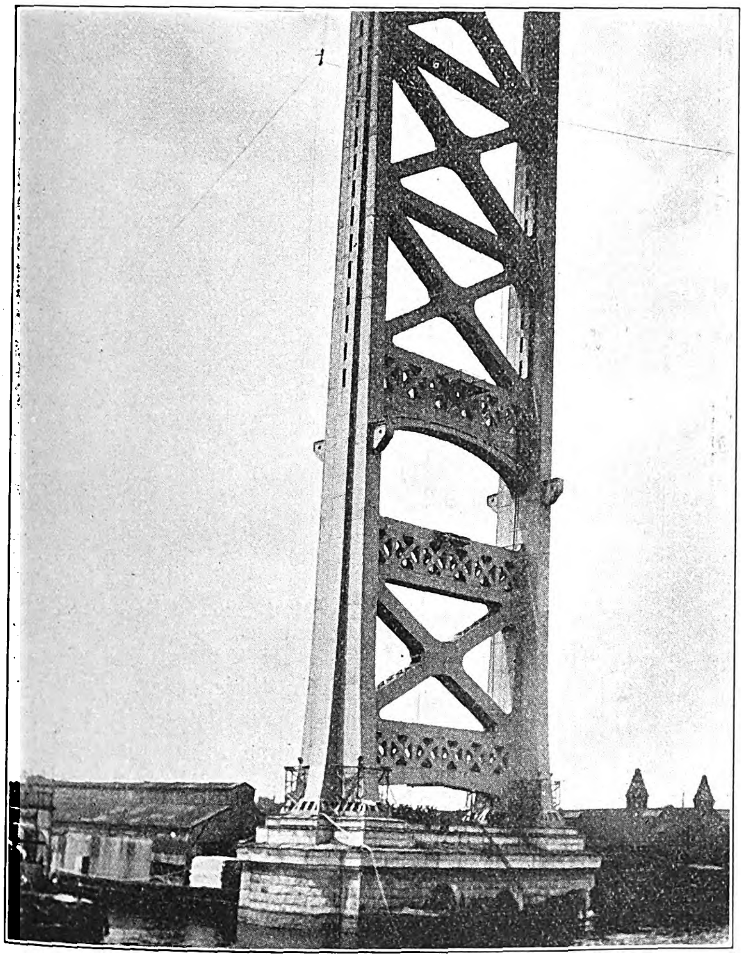

FIGURE 2
PHILADELPHIA TOWER. HOISTING FIRST ROPE FOR FOOT-BRIDGE

The Driving Machinery

The machinery for operating the wire-spinning was located on the Philadelphia anchorage and consisted of a heavy-duty, mill-type, 50-h.p., back-geared motor directly connected to mitre gears on a vertical shaft which carried the main hauling-rope traction-wheel, 6 feet in diameter. This machinery with the necessary idler and deflection sheaves was located on the centre line of each main cable at the rear of the anchorage. An endless loop of ¾-inch plow-steel hauling rope for the cable-spinning work was attached to this driving machinery in the usual way and extended along the spans from anchorage to anchorage over the centre line of each cable. At the Camden anchorage the loop or endless-rope passed around an idler sheave attached to a timber frame anchored to masonry which had provision for taking up a considerable amount of slack as the hauling ropes stretched out in use.

Adjusting the Foot-Bridge Cables

As soon as the first 2¼-inch rope was suspended in place over the Delaware River, its sag was measured in the main and side spans by level and transit and the length computed. This was repeated for one rope of each of the four foot-bridge cables. The lengths of these ropes were computed from the sag data obtained and then instructions were given, to the superintendent in charge of the work, for cutting off and socketing the ropes to the computed unloaded length required for the foot-bridge cables. The two remaining ropes forming each of the four-foot-bridge cables were then hung to the same sag as the one already in place, and cut off and socketed. The ropes were then moved through their saddle bearings on the main towers until they were hanging at their theoretical unloaded mid-span sag in main and side spans, and U-clamps placed around each cable at the river face of the main-tower foot-bridge cable saddles to prevent possible slipping of the cables into the land span due to a considerable unbalance of rope-pull or, technically speaking, a difference in catenary parameters.

Adjusting the "Pull-Back" Ropes

The four 2¼-inch diameter pull-back ropes from the main-tower tops to the anchorage on each side of the river, previously mentioned, were then cut to their computed unloaded lengths, socketed and put in place. Some ingenuity had to be exercised in placing these ropes, due to the stretch cut out of their final length, amounting to nearly five feet. The ropes already attached to the temporary hitches on the top transverse portals of towers were pulled back, one at a time, by a double set of three-sheave block tackle, until the ends could be caught by two of the 40-ton pulling-jacks to be used later in the construction of the main cables. In order to get lead enough for the hydraulic jacks to work, a length of double extra-heavy hydraulic pipe and a heavy square plate washer at its outer end were put on the end of the rope before socketing, as illustrated in Fig. 3. The inner end of the hydraulic pipe bore against the face of the rope socket. A yoke composed of two channel-beams straddled the rope and bore against the washer on the end of the pipe. The two 40-ton pulling-jacks had their plunger ends attached by pins to this yoke and the cylinder ends of the jacks were pin-connected to similar yokes straddling the eye-bolts attaching the rope socket to the cast-steel bases of the inclined cable bents, the latter yokes being in bearing against extra nuts on the threaded shank of eye-bolts as near the base of the column as possible. It was then an easy matter to put the final strain of approximately 132,000 pounds on the rope and, when all four ropes were connected and stretched up to the same sag, to have the tower top bent shoreward to the desired deflection of 11 inches from plumb position.

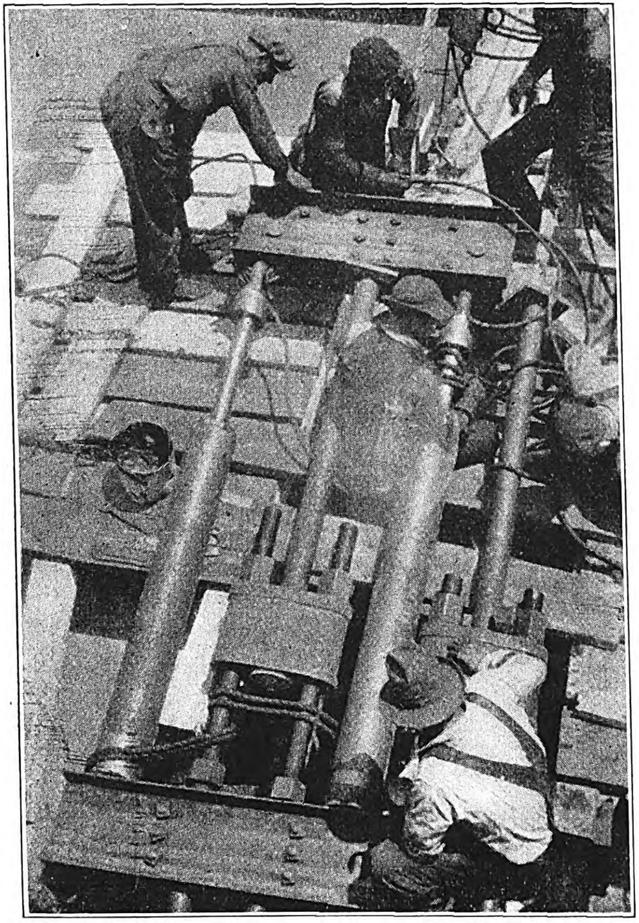

FIGURE 3

HYDRAULIC TACKLE FOR ADJUSTING "PULL-BACK" ROPES

Erecting the Foot-Bridges, Storm Cables, Cross-Bridges, and Gallows-Frames

The work of laying the timber walks then proceeded in the main span from the tops of the towers towards the middle and, in the land spans, from the tops of the towers towards the anchorages, as shown in Fig. 4. The panels of foot-walk already assembled with one floor-beam attached to each panel were then hoisted from the base of the tower to the top and placed on the foot-walk in their order. Each panel beyond the first one placed was landed on top of the walk and skidded along same to its place until the walk was completed, a matter of about five and one-half days. The storm cables for the main and side spans, already cut to computed length and socketed, were hoisted to the tops of the main towers. They were then laid along the foot-walks, one on each side; the points for attachment of suspenders were located by measurement and the suspenders attached to them. The other end of each suspender measured to figured length was laid over the side of the walk and attached to its point of suspension from the foot-walk cable. After the completion of this work, the 2¼-inch-diameter storm-cable ropes were lowered over the sides of the foot-bridge and their ends pulled out to the connections at the base of the tower and on the inclined bents at anchorages. They were then adjusted to the desired initial stress of about 10,000 pounds each. The three main-span cross-bridges, already assembled complete on a barge, were then hoisted to their respective places and attached to the underside of the foot-walks. The side-span cross-bridges were placed in a similar manner, but the work was more difficult to accomplish

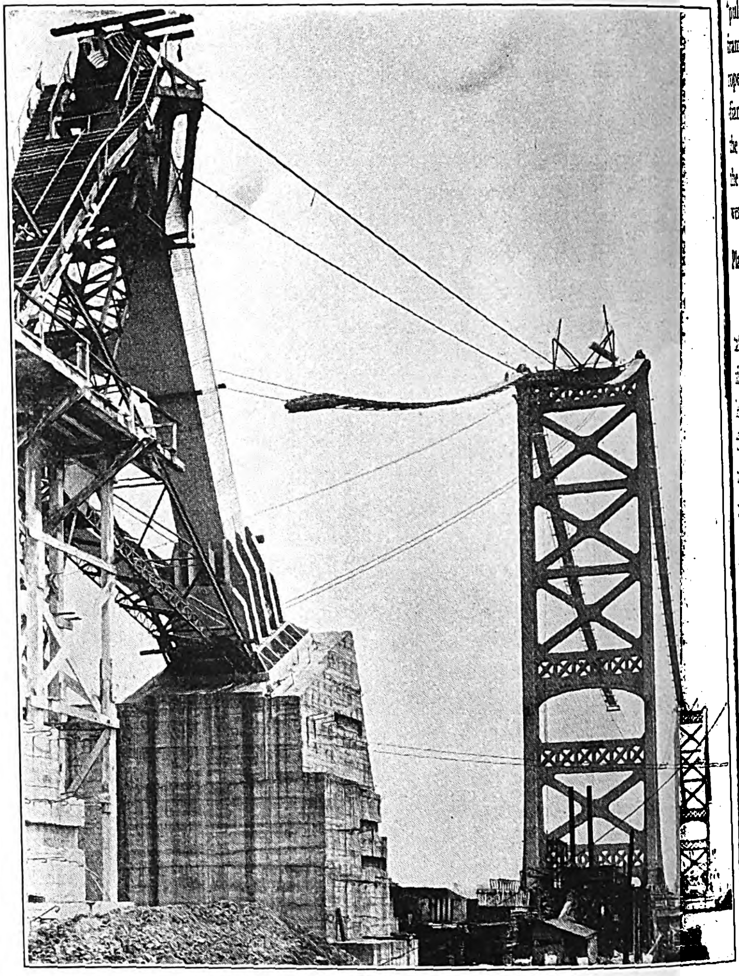

FIGURE 4

FOOT-BRIDGES—PHILADELPHIA SIDE, LOOKING EAST FROM BESIDE ANCHORAGE on account of the trouble in getting them past the "pull-back" guy-ropes already in place. The gallows-frames for supporting the travelling-sheave hauling ropes were then set up on the foot-walks, the ¾-inch-diameter hauling ropes were stretched in place over the spans, and all the small details in connection with the stringing machinery, too numerous to mention, were completed.

Placing the Guide-Wires

The next operation, one requiring careful computation and accurate work in the field, was the laying of guide-wires across the spans and their correct length determination. The guide-wires are made of the same size wire as the main-cable wire; as a matter of fact, the wire was taken from one or more of the reels of wire already placed on the anchorages.

Adjusting the Guide-Wires

Preliminary to the description of the adjustment of the guide-wires, it will be well to explain their function. The guide-wires may be described as measuring rods or means used for getting the approximate lengths of the various strands of the cable at the beginning of their spinning. The final lengths of the strands are determined by their position in the cable saddles and on the anchor-chain connections at the ends, and by their accurately measured theoretical sags in the spans.

One guide-wire for each cable was laid in the strand-groove of the main tower and inclined anchorage-bent saddles, and its end was attached to the pin of the pair of eye-bars of the anchor chain at each anchorage for the selected one of the five bottom strands of the main cable it was intended to measure. It was then stretched up to a predetermined sag in the main span; the measurement of this sag was made by an engineers' level set at a convenient elevation in the Philadelphia tower to observe the target on an inverted level rod projected down through the foot-walk at the middle of the span. A graphical diagram of elevations of the centre line of the unloaded main cable at mid-span had been made from the computed elevations for various temperatures and bent positions of the tower tops. From this diagram, and with a standardized thermometer hanging nearby and with the positions of the tower tops known from observations of plumb lines hanging inside of the tower columns, the engineers set the first guide-wire to its correct theoretical sag in the main span. A point on this guide-wire was marked on it and in the saddle-groove for observation, and the guide-wire was clamped at both ends of the saddle to prevent its slipping either way in the saddle. The guide-wire sag was determined in a similar manner in each land span, but the work was a little more complicated as the middle-point of span where the sag was to be measured had to be determined by use of an engineers' transit set on a transverse station point at some distance laterally from the axis of the bridge. On the Philadelphia side the point was on the roof of a pier shed some distance north of the bridge. On the Camden side the station point had been established on a dock some distance south of the bridge. At an engineers' level in the Philadelphia tower for that side span, and in the Camden tower for the Camden side span, the sag elevation was read on an inverted level rod extended below the foot-walk floor. A graphical diagram for the land-span cable sags similar to the main-span diagram was used with temperature and tower deflection observations considered as before. Thus the total length of the first guide-wire for each north and south main cable was determined and permanently marked on the wire. The three remaining guide-wires to be used in the construction of the strands were then laid one

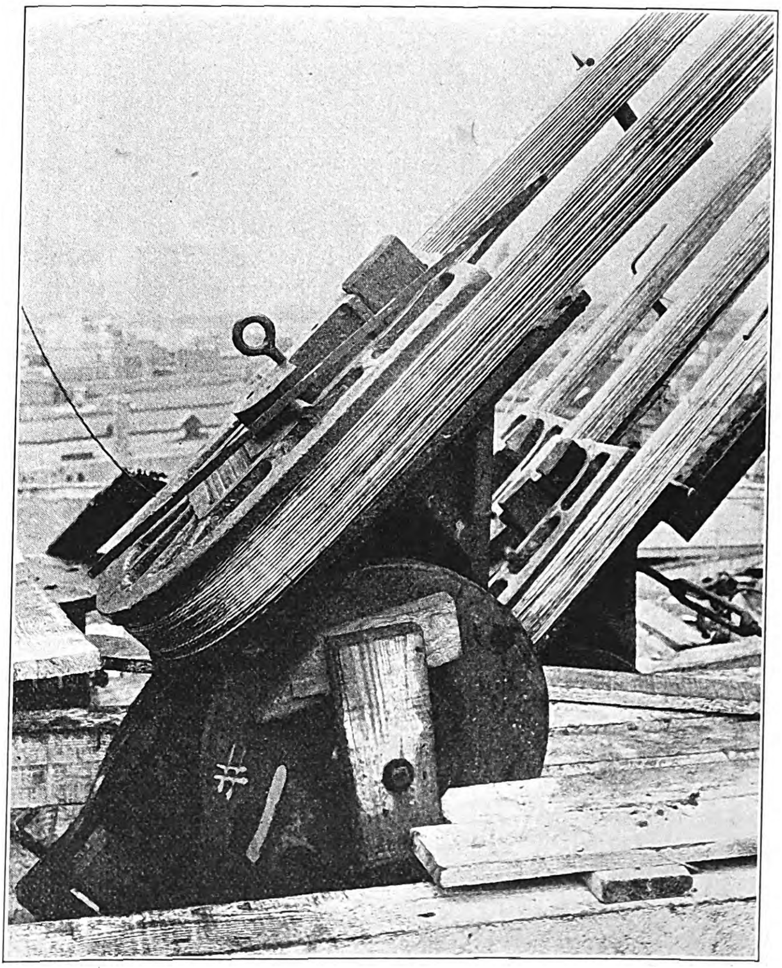

FIGURE 5

CABLE STRAND ON SHOE AT EYE-BARS

by one alongside of the guide-wire already hanging in its place and set at the same sag, and were thus measured in length between certain fixed points. A table of centre-line lengths of all of the sixty-one strands of each cable had been computed and checked so that now all that was necessary to change the guide-wire from one strand length to any other was to add or subtract its difference at each end where adjustment had been provided by means of a turnbuckle for the purpose.

Stringing the Wires

At the commencement of stringing of a set of strands, the guide-wires are first adjusted to the centre-line length of these strands by means of the turnbuckles provided at the ends, and are hooked to the eye-bolts in the strand-legs already set in place with the shoes attached. The guide-wires are then laid in the strand-supporting sheaves on the main-tower and inclined-bent main-cable saddles, and hang free in their balanced sags ready to measure the first wires of the strands when laid in place. This is well illustrated in Fig. 6, where the shoes of two strands are shown in place on the legs with the guide-wires attached. Around the nearer one of these shoes is seen the bight of wire thrown preliminary to stringing. The end of this wire is made fast at some convenient point a short distance away, probably in this case the temporary steel-bent supporting the cable strands at the splay point. Enough of the wire is then pulled off the reel from which the strand-wire is being strung and the bight or loop thus formed is thrown around the travelling sheave that is to haul it to the opposite anchorage fastening. Simultaneously the same operation is being conducted on the opposite side of the river for the corresponding strand which is being spun (for the same cable) by the travelling sheave attached to the other part of the travelling rope and carrying a strand from a reel of wire on the other anchorage. As soon as the workmen adjusting the wires on the Camden anchorage were ready to start the stringing, the signal-bell button was pressed and, if all was ready at the Philadelphia anchorage, the motorman there started the hauling-rope sheaves across the span. As soon as the travelling sheave passed the saddle on the inclined bent, the standing or "dead" wire of the bight being hauled across the river was guided by the workmen into the strand-supporting sheaves there, and the running wire was guided into small carrier sheaves that support the running wire in its passage across the span. These small sheaves were also located at intervals along the walks, in fact at every gallows-frame supporting the main travelling rope, and at these same points were also located suitable hooks to confine the standing or "dead" wire and prevent it from surging up and down to the discomfort and danger of workmen as the strain on the wire varied. When the travelling sheave passed the main tower, and the dead wire had been laid in the strand-supporting sheaves and the "live" wire guided into the small wire-supporting sheaves, the regulation of side-span "dead" wire was begun. The wire-regulating crew on the main tower took hold of the wire with the "come-alongs," or wire clamps, to which were attached small double-sheave tackle-blocks which one man manipulated along the main-span walk, pulling up or slacking the wire until it was adjusted to the same sag as the guide-wire, as determined by the wire regulator stationed at midway of the side span. The wire was then securely clamped to the guide-wire at the main tower and tied to it by means of short twine lashings at intervals of fifty feet or so along the span. A pencil mark was also made across the guide-wire and the wire just regulated at the saddle, to detect any possible slipping of wire. The signal was then passed to the main tower on the opposite side of the river that the "dead" or standing wire was then ready to be regulated in the main span and, as soon as the traveling sheave had passed that tower, the adjustment of the main-span wire by the wire-regulating force on that tower was begun. This regulator at mid-span signalled to the men at the tower to raise or lower the wire, pulling in or slacking on the tackle, attached by the "come-alongs" to the "dead" wire, until it was hanging parallel to, or with the same sag as the guide-wire in the main span. The "dead" wire was then clamped to the guide-wire at the tower and lashed to it at intervals of fifty feet or so throughout the span by the twine mousings as previously mentioned. If the work progressed smoothly, by the time the traveling sheave reached the anchorage and the bight of wire hauled across by it had been removed and thrown around the

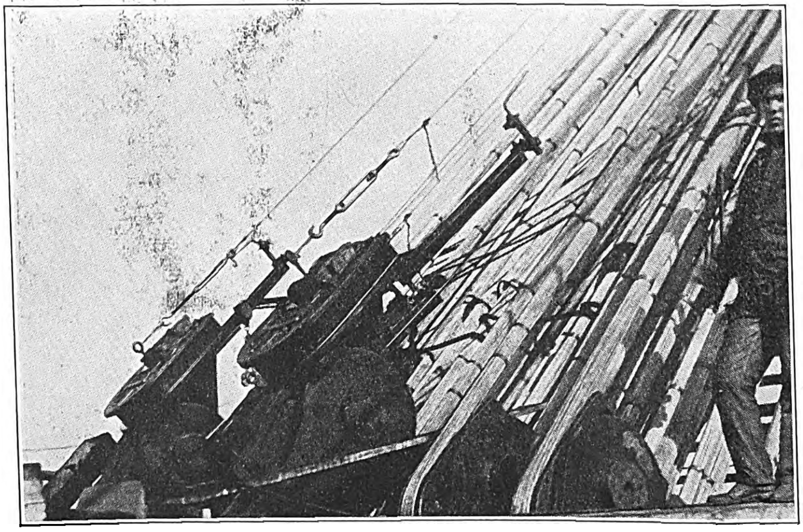

FIGURE 6

STRAND-SHOES IN PLACE FOR SPINNING—WITH GUIDE-WIRES shoe with the "dead" wire on the same side of the shoe as at the opposite anchorage, the "dead" wire was ready for regulating in that land span. This was done as soon as a bight of wire for the adjacent strand being strung from the reel on that side of the river had been thrown around the sheave and was started on its way across the span again in the opposite direction.

While the travelling sheave was going from that anchorage to the main tower, what had been the "live" or running wire on the other strand would be regulated in the land span and a signal passed to the opposite tower that the main-span "live" wire was ready for regulating. Then the same regulating force would begin the regulating of the "dead" wire of the bight of wire being hauled by the same sheave to the opposite side of the river. As soon as the men on the opposite tower regulated the "live" wire of the first strand and signalled to the crew at the anchorage that the land-span wire was ready for regulating, the tower crew would begin the regulating of the "dead" wire, in the main span, of the other strand being strung from the Camden anchorage, if the travelling sheave hauling the bights for that strand had passed the Philadelphia main tower. If there was no unusual delay, the regulating of the "dead" wire above-mentioned would be completed by the time the travelling sheave had reached the Philadelphia anchorage, the bight of wire removed from the sheave and laid around the shoe and another bight for the opposite strand placed on the sheave ready for another trip across the span. The "dead" wire would be regulated in this land span and, immediately afterward, signal would be passed to the main-tower crew to take up the regulating of the "live" wire of this strand which had already been removed from the small running sheaves and placed in its proper position in the strand-supporting sheaves. Thus a round trip of one travelling sheave has been made, laying two wires in each of two strands on one side of the main cable; that is, it has strung two wires of one strand from a reel on the Philadelphia anchorage and returned with two wires from a reel on the Camden anchorage for the other strand on the same side of cable. At the same time, the travelling sheave on the opposite side of the cable, being operated by the other part of the travelling-rope loop, was similarly engaged on two more strands of the same cable. In this manner four strands of one cable were being spun at the same time. An entirely separate plant was performing the same operations on the other main cable, so that eight strands of the two main cables were being spun at the same time. When a dozen wires had been regulated in place in a strand, the corresponding guide-wire was removed. This was speedily accomplished by lifting up the bight at each tower and laying the guide-wire along the outside of the walk.

Handling the Completed Strands

As soon as all of the 306 wires of each of the four strands of a main cable had been strung in place, or all of the wires of any one of these strands were in place, and the two ends of wire forming the completed loop or skein had been brought together under the initial load stress, cut to correct length and spliced, the work of squeezing up the strand by the strand-tongs, placing the flat-wire seizings, and getting everything in readiness to remove the strand from the temporary supports and fastenings and lay it in place in the cable was begun.

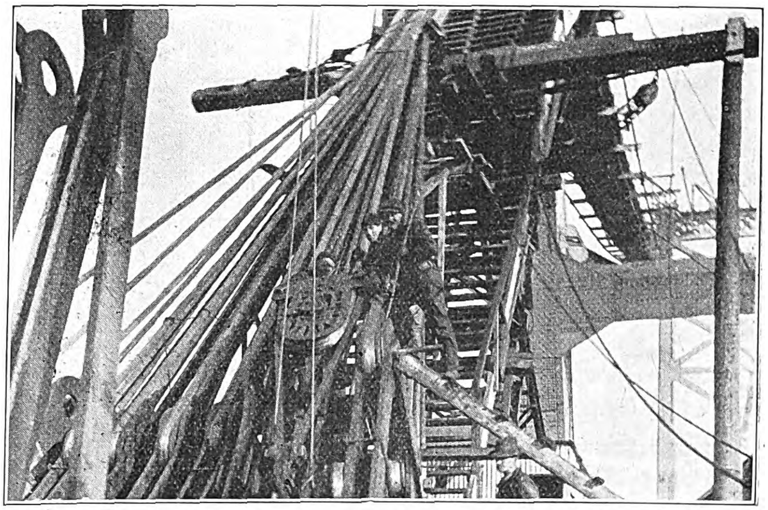

FIGURE 7

PHILADELPHIA ANCHORAGE, NORTH CABLE—REMOVING SHOE FROM STRAND-LEG

At the anchorage, 60-ton capacity hydraulic pulling-jacks were attached to one of the strands, the anchorage-end being connected to a special hook engaging a pin of the anchor chain. The piston-end of the jack was attached to a wire-rope pennant which, in turn, was pinned to what is termed a "bridle." The "bridle" is illustrated in Fig. 7 and is here shown in position on the end of the strand. It consists of two flat bars which rest against the square end-face of the strand-shoe and straddle the two parts of the strand. These bars are bolted together with filler plates between them to serve as spacers and bearing for the strand-shoe and, by means of turned pins at their ends, are connected to the square steel bridle-bars which engage the wire-rope pennant at their lower end by means of a turned pin. When ready to release the strand from its temporary anchorage on the strand-leg, the independent hand-pumps operating the pulling-jacks were started. As soon as the strand pressure was off the strand-leg, the latter was removed from the anchor-chain pin and one of the eye-bars was also slipped from this pin. The strand-shoe was then turned from the horizontal position it occupied during the stringing to its final vertical position and placed on the pin with a predetermined thickness of shim plates between the pin-bearing block and the strand-shoe bearing. The eye-bar was then replaced on the pin and the pulling-jack strain released, leaving the strand-pull on the pin, but the "bridle" was not removed from the strand-shoe attachment at one anchorage until the adjustment of the strand was completed across the span working from that anchorage.

At each main tower and on the inclined cable bents at the anchorage, the same strand was connected to what is termed a "balance-beam" as illustrated in Fig. 8, this consisted of two channel-beams of suitable length and strength for the load to be lifted. These beams were riveted together with a space of ¾ inch between the webs for the insertion of the lifting links which were connected to the "balance-beam" by pins through the webs. The "lifting links" were of varying length to conform to the curve of the cable in the saddles and were attached to the strands by means of a loop of ½-inch-diameter steel rope and clevises.

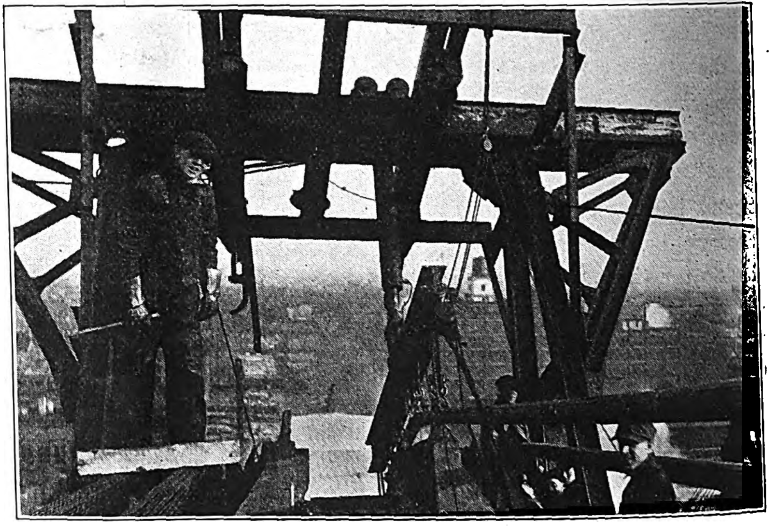

FIGURE 8

NORTH CABLE AT CAMDEN BENT—PLACING STRAND IN SADDLE

Regulation of the Strands

As soon as the first strand had been attached to its pin at the anchor chain and had been lowered into its groove in the cable saddle at the inclined bent and the main tower, its regulation to true sag elevation in that land span was begun. The operation here was performed in precisely the same manner as had been employed for getting the guide-wire length as previously described, using the same graphs, engineers' transit and level, and standardized thermometer. After the land-span segment had been regulated to the desired sag by the movement of the strand in the main-tower saddle towards the land or river, by means of steamboat ratchets attached to the strand near the ends of the saddle, as or if found necessary, the main-span segment was regulated in the same manner to its proper sag, and the strand was marked at the tower saddles so as to check possible slipping through the saddles. Then the opposite land-span segment was regulated, thus completing the operation of setting the first strand of the cable, provided there was enough leeway remaining at that strand-shoe for the insertion of the necessary amount of shims to make the correct length of strand as determined by the sag measurements. If there did not happen to be sufficient leeway in the slotted strand-shoe pin-hole at that anchorage-end to adjust the strand to correct sag in that side span, the strand would have to be adjusted back to the other side of the river where there was leeway for shimming to get the correct length. This will happen at times in any cable construction, in spite of guide-wire measurements of the strand at the beginning of stringing. The tendency is always for strands when completed to be a little longer than the guide-wire length to which they are initially set.

After the completion of the first strand in place and the checking of sag elevations sufficiently to satisfy the engineers of its correctness, the instrument work was no longer required in setting the remaining strands. All the strands lying in the same horizontal layer in the hexagonal-shaped strand-cable were set to same sag and the next layer above was set, strand by strand, so that they touched the strands below without bearing hard against them. If any one strand was too long, it immediately showed in the work, by the spreading of the two adjacent strands below it. Frequently it became necessary to readjust strands after they had been satisfactorily set on account of misjudging the temperature of the strands before they were laid alongside of those already in the cable. The only time a reliable survey of position of the strands in the cable could be made was the early morning after they had arrived at a uniform temperature before the sun had begun to warm up the more exposed strands, or during a protracted period of cloudy weather.

After about twenty of the strands of each cable had been completed and regulated in their place, they would spread out so in mid-spans on account of the sun's rays heating the top strands and elongating them that they occupied too much area of the foot-walks for the convenience of the workmen; therefore the superintendent in charge of the work devised a timber yoke having the hexagonal form of the strands in the cable with strand-grooves cut in the three faces. These yokes were applied at intervals of about two hundred feet by means of wire ties across the top over the strands already in place, and proved very effective in keeping the strands in their respective positions in the hexagonal section and in preventing further annoying spreading of the strands during the sunny part of the day. These yokes were extended after the strand construction had been completed to and including the middle row of nine strands, to form the inward sloping hexagonal sides above the middle of the cable.

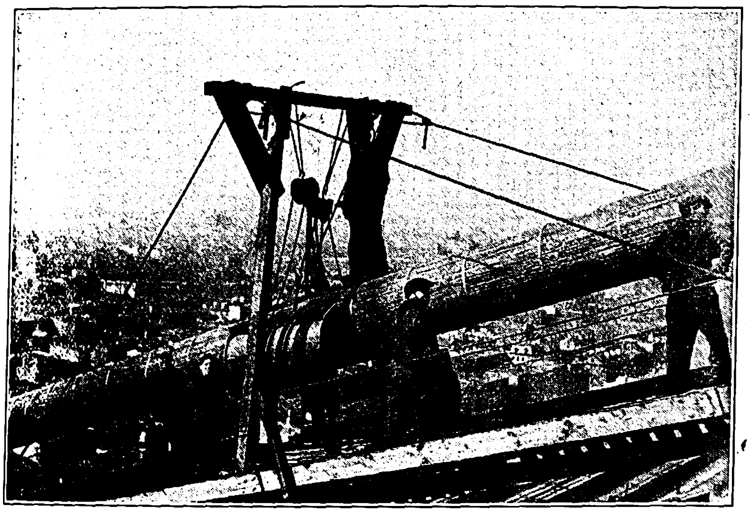

FIGURE 9
ERECTING CABLE-BAND—PHILADELPHIA SIDE SPAN—NORTH CABLE

The Squeezing of the Cable

Immediately upon the finishing of the spinning and regulating of all of the strands in a cable, the squeezing of the sixty-one strands into the final cylindrical 30-inch-diameter cable was begun.

Placing the Cable Bands

Upon completion of the squeezing, the cable-band positions on the cables were located by careful steel-tape measurements along the cables, working from both towers and checking with the computed length of the cable, also by transit check lines from one cable to the other at the middle of the river span. The cable bands were then applied in the usual way, working from main towers towards the middle of the main span and towards the anchorages in the land spans. The cable bands were hoisted to the tops of the towers by tower derricks, and were skidded along the walk on sleds made for the purpose, taking a half-band at a time, the heaviest of which weighed about 1,700 pounds. The bands were placed on the cables by means of a gallows-frame, straddling the cable from which were suspended two differential chain-hoists as shown in Fig 9. The two half-bands were hoisted separately, and then brought together and enough bolts inserted to hold the band in place. Another crew of men followed along, inserting the remainder of the bolts, and a third crew followed, screwing up the bolts with socket-ratchet wrenches. By an examination of the photograph it will be observed that at the point where the half-bands are being hoisted, there are two seizings that are nearer together than the others. These seizings were exactly located so as to come under two grooves provided on the inner face of the cable bands to receive them, and their purpose was to hold the wires in place against possible dragging while placing the bands. It is the speaker's belief that their use here, and on the Bear Mountain Bridge for the first time, was eminently satisfactory and worth-while.

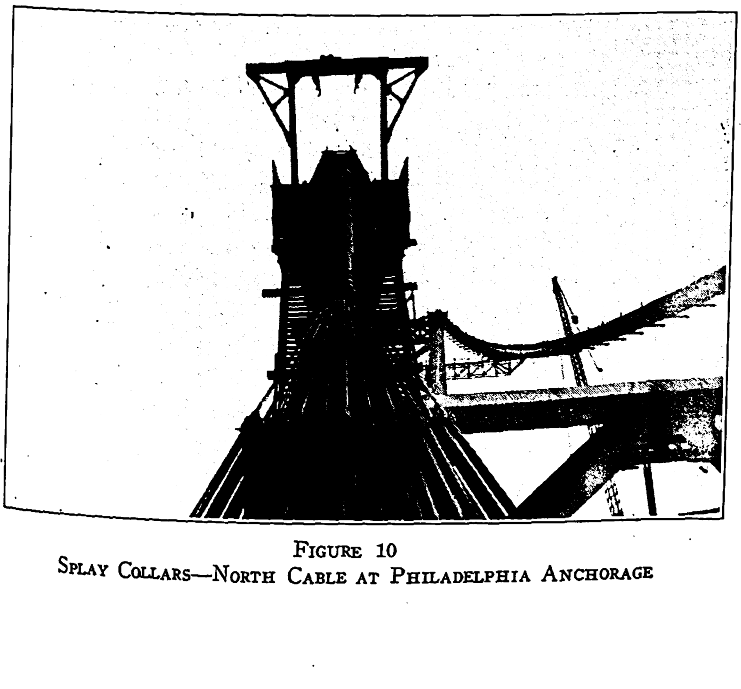

FIGURE 10
SPLAY COLLARS—NORTH CABLE AT PHILADELPHIA ANCHORAGE

Lashing the Foot-Walks to the Cables

Upon the completion of the placing of the cable bands, the work of lashing the foot-walks to the main cables was begun and continued to completion, and then the storm cables and pull-back guy-ropes were removed. These were all cut loose at their end-fastenings, hoisted up and laid along the foot-walks, and later dragged over the walks to the Camden land span, where they were lowered to the dock on the north side of the bridge, cut up into suspender lengths and socketed. The three cross-bridges of the main span and the two in each land-span footbridge were then lowered to scows in the river and, in the case of the Philadelphia land span, upon the dock underneath the bridge, and dismantled.

Removing the Foot-Bridge Ropes

Now with the foot-walks suspended from the main cables, the main foot-bridge cable-ropes were disconnected at the anchorage-ends, and were hoisted upon the walks and lowered, one by one, to the Camden dock before-mentioned, where they were also measured and cut to lengths and socketed for suspenders. All the 2¼-inch-diameter suspender rope used for the temporary works of the main-cable construction furnished about 61,000 lin. ft. of finished suspenders for the main superstructure; the remainder of the approximately 105,000 lin. ft. required was cut from 44,000 lin. ft. of new rope, ordered and furnished under contract No. 13 of the Bridge Commission, which contract also included the main cable bands and fastenings and the two lines of 1-inch-diameter strand hand-rail ropes over each main cable with their connections.

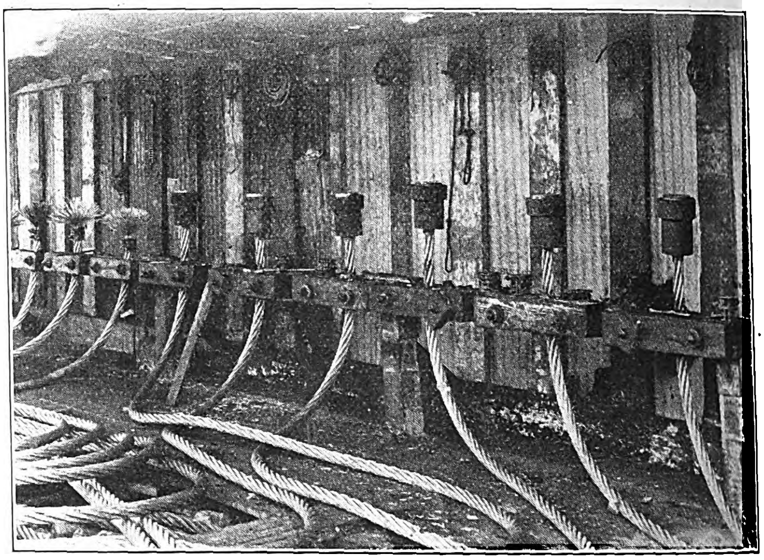

FIGURE 11
SUSPENDER ROPES—SOCKETING FRAME

Measuring, Cutting and Socketing the Suspenders

The work of measuring, cutting and socketing of the suspenders was done, as before mentioned, on the Camden dock where a straight and level runway, long enough to accommodate the longest loop of suspender, was constructed of timber planking. At the shore end of this runway, a form was made to conform to the profile of the suspender groove around the main cable bands and the drawing together of the two parts of the suspender loop a fixed distance below the cable (from which point they hang parallel to the connection on the vertical post of the truss). In measuring the suspenders, they were laid around this form, stretched out along the runway in the two parallel lines, and put under sufficient strain to pull them straight, and then measured to their respective computed unloaded lengths. The ends were then seized in the usual way, and the ropes cut to the measured lengths by hydraulically operated shears. The button-end sockets are shown in place on ropes in Fig. 11. The socketing was done in the usual way, except that, in place of wire seizings around the rope adjacent to the socket to prevent the unlaying or untwisting of the strands of the rope, two special rope-clamps, as shown in the photograph, were used. The wires of the strands were untwisted, separated and straightened, then wiped and cleaned of all grease possible by use of kerosene oil. The end of the rope, then looking like a stiff bristle broom, as illustrated in Fig. 11, was dipped in a mixture of equal parts of muriatic acid and water until all traces of grease and most of the galvanizing had been removed. Then it was dipped and washed in clean water and wiped dry before being placed in the timber clamps shown in Fig. 11. The wires were then bound compactly together at the end by a temporary wire seizing, and the cast-steel button-end socket with conical opening or basket was placed on the rope, with the ends of the wires flush with the end of the socket when the wire seizing had been cut away and the wires spread out and evenly distributed to fill the "basket" opening. Fire-clay or other suitable damming material was then applied around the rope at the small end of the socket, to prevent leakage of the spelter, and the socket was poured full of melted zinc to a finish projecting about ¼ inch beyond its end, as shown in Fig. 11.

Placing the Suspenders

As the ropes were socketed, they were labelled with metal tags wired to them, indicating their position on the cables, and were then laid on the deck of a scow moored along the front end of the dock. The scow was then towed along under the spans, and the suspenders were hoisted to their respective places by a single line leading from the top of the main tower through a gate-block hanging from the cable band. The free portion of this line was clamped to the suspender rope a little beyond its middle point, at the end next to the socket, and at an intermediate point, with hemp mousings at intervals of a few feet between the main clamps. As the suspender rope was hoisted up and laid in the groove over the cable band, the clamps and mousings were removed and the rope was allowed to fall down on the other side of the cable until its middle point was over the centre of the cable. The suspender clamps were then put on the loop of rope about four feet below the cable, completing the hanging of one pair of the suspenders. The short suspenders along the middle of the main span were handled two at a time, or all the four suspenders at a cable band were placed in one lift.

Placing the Hand-Rail Ropes

The four one-inch-diameter strand hand-rail ropes, previously cut and socketed to the computed lengths, were attached to their connections at the main-cable saddles on the inclined cable bents and on the main towers, adjusted to the desired sags in the three spans, and attached to the ¾-inch-diameter rod-stays connecting them to the main cable bands.

Dismantling the Foot-Walks

As soon as the suspenders had all been placed on the main cables, the cables and suspenders painted, and the cable bands, hand-rail ropes, and attachments completed, the main foot-walks and all other temporary works were removed. The foot-walks were taken apart and, as far as possible, lowered to the deck of scows in the river.

Handling the Wire at the Bridge Site

One main point of difference in the operations on the Delaware River Bridge cable-work from recent previous cable construction was that of handling the main-cable wire. Instead of the wire being spliced at the place of manufacture, before shipping to the bridge site on drums or reels, it was shipped from the manufacturer's plant in five-foot diameter coil lengths of approximately 3,000 feet, and stored in the long dock-shed back of the Camden anchorage. In this shed were installed the necessary threading machines, swifts, reeling machines, oil bath tanks, etc.; and the wire was there spliced, oiled, and placed on the 80,000-foot capacity cable-spinning reels. For the strands of the main cable that were strung from the Camden side, these reels were delivered by small railway trucks to the anchorage, and hoisted to their places in the reel-stands by the derrick on the anchorage. The reels of wire for the strands strung from the Philadelphia side were loaded on a motor truck, ferried across the river, and delivered in the reel-stands by the stiff-leg derrick on top of the Philadelphia anchorage.

The appliances for splicing and reeling of the wire, designed and installed by the American Cable Company in a building on the Camden side of the river, were the most complete and efficient ever used in cable building, and reflect great credit on the designer. They never failed once to meet the demand for wire on the work.

Handling of the Field Organization

As the time was limited for the completion of the bridge cables, how best to accomplish the task was a question left to the constructor to solve. The plant was designed, in the light of previous experience, to produce economically the maximum output of wire in place in the cable, and the method of accomplishment was left to the superintendent in charge of the work for the constructor. The superintendent chose to do the work with one twelve-hour shift per day, (6:00 a. m. to 6:30 p. m.) instead of two or more shifts of eight hours each. Flood-lights were provided for the early morning and late evening hours and signal lights, telephones and signal bells were provided for use in signalling the wire-adjusting orders both during the hours of darkness and during foggy weather. Although the hours were very long, most of the work was not too arduous for such hours and the workmen all seemed satisfied. It was a rather severe test of physical endurance and stamina at times when the weather became severe, but there was not a single desertion to the speaker's knowledge, in spite of frequent frost-bitten fingers, etc.; the men were most loyal to the work.

DEPARTMENT OF AGRICULTURE
Washington

Protection of Reservoirs

Suggestions that may add to the value of water-power and water-supply developments are made in a bulletin, entitled "The Financial Limitation in the Protection of Reservoirs," by W. W. Ashe, just issued by the Forest Service. It is of interest to investors in water power and in municipal water supply securities, as well as to managers of such properties, and to engineers.

Storage of water is becoming a recognized factor in hydroelectric development, just as it is necessary in most cases for municipal supply. This bulletin shows that with storage there enters the problem of siltage through the erosion of soil, an insidious agency which may cause loss of pondage and consequent reduction in the capacity of reservoirs.

The rapidity of erosion and of silting up of reservoirs is affected by different physical and meteorological conditions in the different regions of the United States. Over the greater portion of Northern and Northwestern United States and in Canada erosion is not the serious problem that it is in parts of the Southeast and particularly in portions of the Southwest. The bulletin calls attention to the high silt burden of certain streams and the rapidity with which storage capacity of reservoirs is reduced, as in the case of the Colorado River (of Texas). The reservoir at Austin on this river lost more than half its capacity within ten years. Many other streams carry a silt burden fully as great as that of the Colorado. On the basins of certain of these streams the surface conditions are such that erosion can be materially reduced. On others the conditions are such that erosion can be only slightly lessened. There are other regions where protection of the surface is highly efficacious in reducing erosion.

It is shown that it is possible to ascertain the rate of silting which is taking place and from this to determine the capital value of the storage capacity, the loss of which might be expected within a given period, and that power and water companies are justified in making additional expenditures which would be within the capitalized value of the storage capacity which will be preserved.

Copies of the bulletin, which is designated as Department Bulletin 1430-D, can be obtained from ENGINEERS AND ENGINEERING.

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The book should be particularly valuable to all interested in the utilization of wood and cellulose by chemical methods.

The Hydrous Oxides—By Harry B. Weiser, Prof. of Chemistry, Rice Institute. 452 pages, 31 illustrations. $5.00.

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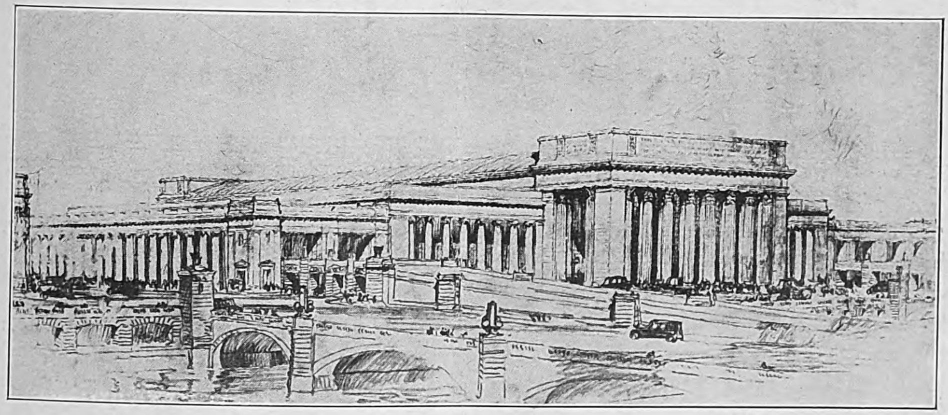

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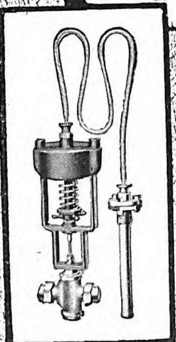

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Philadelphia's New Passenger Terminal*

By E. B. TEMPLE
Assistant Chief Engineer, Pennsylvania Railroad

THERE has been a keen interest displayed in the plans of the Pennsylvania Railroad Co. for passenger terminal improvements in the City of Philadelphia. This interest is natural and encouraging, and I feel grateful to the Engineers Club for the opportunity to show some of the more important of these general plans, and to tell you what is contemplated that we believe will be of great moment to the City and surrounding communities.

The agreement of July 13, 1925, between the City of Philadelphia and the Pennsylvania Railroad Company provides for the improvement of certain sections of the city East and West of the Schuylkill River, for the removal of the Filbert Street elevated railroad leading to Broad Street Station, the construction of an underground railway East of the river, with an underground station at 15th Street north of the present Broad Street Station, and a new passenger station west of the Schuylkill River.

The improvements contemplated make it possible for the City to obtain an additional highway 90 feet in width about on the line of Filbert Street, between Market and Arch Streets, to be known as Pennsylvania Boulevard, from City Hall Plaza to and beyond the new station on the west bank of the Schuylkill River; also additional important streets west of the river, notably the West River Drive from its present terminus at Spring Garden Street to South Street and eventually to the proposed University Bridge across the river.

Will Work a Transformation

With the removal of the elevated railroad between the river and Broad Street Station, most of the property of the Railroad Company can be sold for improvements. Some portions will be retained for railroad use, but it is expected that great buildings will be erected on the portions sold, which will bring large amounts to the City in taxes. One can readily imagine the transformation that will take place along the Pennsylvania Boulevard, with stately buildings flanking both sides for nearly one mile.

Let us stand on the north sidewalk of City Hall—turn our faces to the North along Broad Street, the thoroughfare our City has been so proud of for generations; then turn slightly to the West and gaze upon the great Parkway that has been so much and rightfully admired, raise our point of view and behold the beautiful Art Museum at the end of the Parkway in Fairmount Park; now face directly West and visualize on your right the quadrangle or plaza from Broad Street to 16th, and from Arch to Pennsylvania Boulevard, and glance along the shaft of that Boulevard, lined with handsome buildings, commencing at the very heart of the city and extending almost to the eastern facade of the Pennsylvania Station on the Schuylkill.

General Features of Plan

By the terms of the agreement of 1925, the Pennsylvania Railroad will construct this new Philadelphia Station on the west bank of the Schuylkill River between Market and Arch Streets, with low-level tracks, 16 in number, parallel with the river and slightly above the highest water mark, providing a continuous route for through trains and a terminal for incoming and outgoing trains beyond the electrified suburban zone.

High, island passenger platforms, 1500' in length, between each pair of tracks, alternating with island platforms for baggage and mail, will be provided; also ample coach-yards adjacent to the terminal. The present engine terminal, with proper modifications, will be utilized. As electrification of routes continues, this will be gradually converted into a terminal for electric locomotives.

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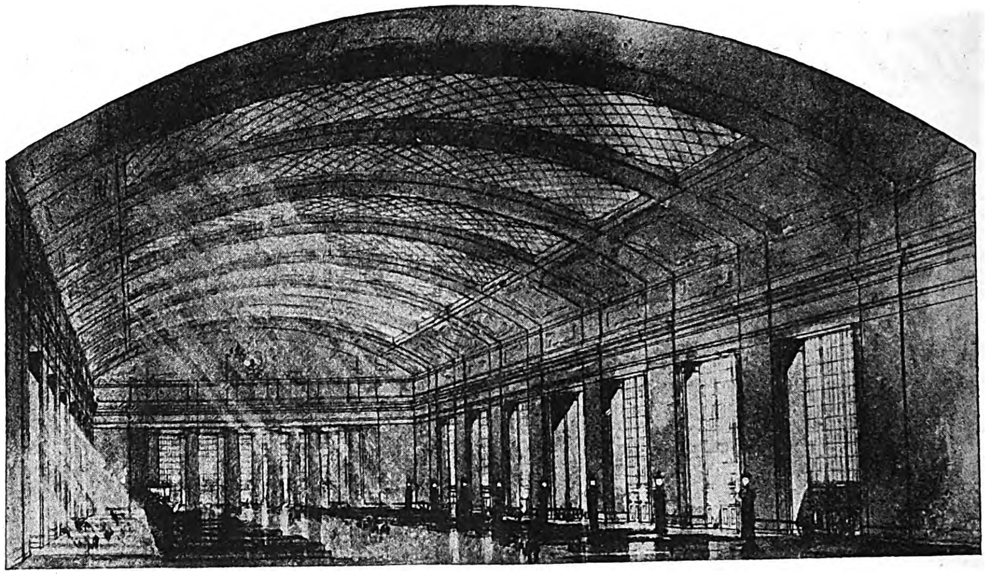
*Address delivered Nov. 26, 1926.



GRAND CONCOURSE—MAIN STATION

On the upper level above the main floor of the station and at right-angles to the through tracks and the Schuylkill River, six tracks with island platforms for electrified suburban trains will be constructed; these tracks will extend over the Schuylkill on a new bridge, and descend to a subway under the Pennsylvania Boulevard, with a portal west of 21st Street, to the underground station at 15th Street.

Description of Station Building

The new main station in Philadelphia will occupy the block between Market Street on the South, an extension of Arch Street on the North, 30th Street on the West and West River Drive on the East, measuring about 700 feet north and south and 500 feet east and west. In this large area, on a level with the surrounding streets, will be located a grand concourse, combining the functions of a waiting room and an arrival and departure concourse 160 feet in width and 460 feet in length. Grouped around this concourse, in locations the most convenient for the passenger, will be ticket offices, dining rooms and restaurants, rest rooms and toilets, parcel and baggage rooms, and other facilities usually found in a terminal of this size; and in clear view will be the entrance to the suburban platforms on the north, and to the proposed station of the Rapid Transit Company at Market Street. Train gates will be in this main concourse, on each side, opening to ramps to each-low-level platform, and in the suburban lobby will be ramps and stairs to the upper platforms; stairs being avoided wherever practicable.

Suburban passengers can reach and leave the suburban concourse without using the main concourse.

As mentioned, separate platforms for baggage and mail will be placed between each pair of tracks on the low-level through station, a condition that will be greatly appreciated by passengers, who will have platforms exclusively for their use. This is the condition we have in the new Union Station, Chicago.

General Architectural Treatment

At the time the agreement with the City was under consideration, various plans of the entire project had been prepared, showing in outline the nature of the proposed improvements. Since then our studies have continued, particularly as to the architectural treatment.

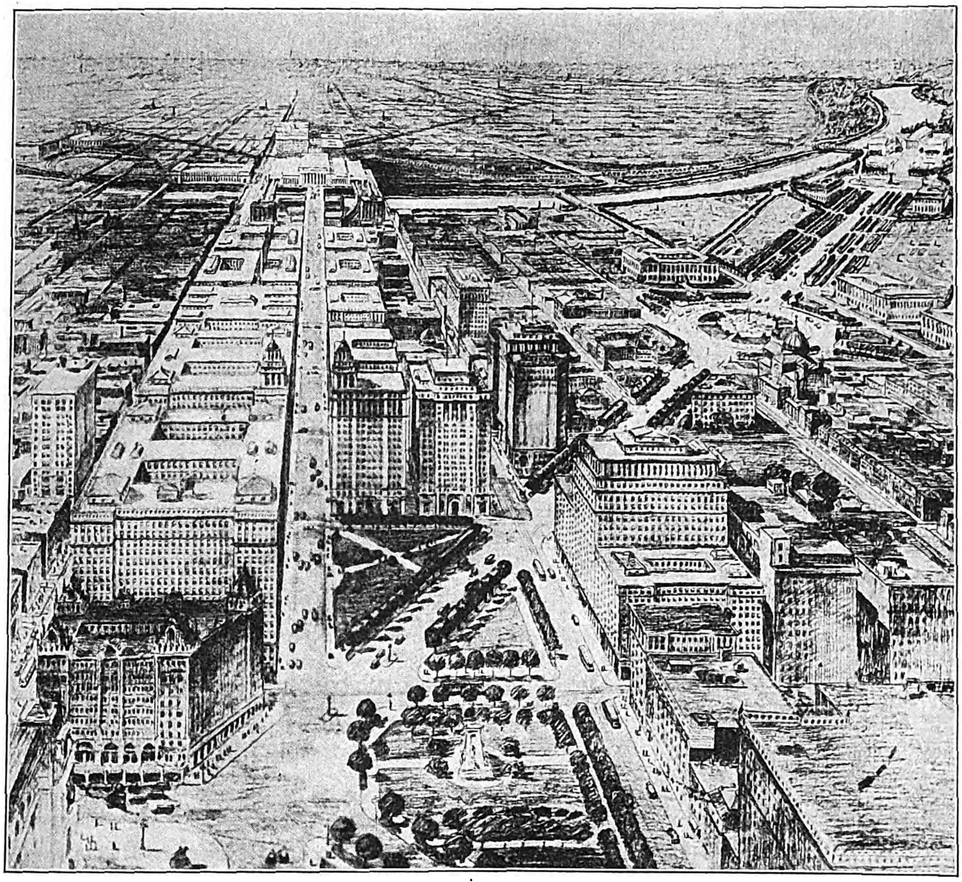
The view from near the Pennsylvania Boulevard, looking at the facade along the Schuylkill and West River Drive, shows the entrance portico, which is duplicated on the west side of the building, for vehicles to drive in through a colonnade of Corinthian columns of extremely impressive proportions. Side pavilions extend North and South of the central feature of the building in a minor order. (See Front Cover.)

The view from the Art Museum shows actual buildings taken from photographs, the lines of the river, the new bridges, and the new station building in perspective. In this view we see the great entrance motifs on the East and West sides of the station and the colonnade on the North side, enclosing the suburban platforms, above which rises the mass of the main building.

Relation to Facilities

The West River Drive between the station and the Schuylkill River will be on a viaduct on the level of Market Street, Pennsylvania Boulevard and the main waiting room, and will pass under bridges carrying the Pennsylvania Railroad suburban tracks on the north side of the Station and the Market Street elevated railroad of the Philadelphia Rapid Transit Co. on the south.

The Rapid Transit elevated can remain practically in its present location, but it would be much bet-



VISTA OF PROPOSED "PENNSYLVANIA BOULEVARD" AND THE PARKWAY

In this drawing the General Offices of the Pennsylvania Railroad, comprised in the present Broad Street Station, are shown at the left foreground of the picture. It is contemplated to leave this portion of the existing structure standing. "Pennsylvania Boulevard," the new street to be created in connection with the station plans, is shown at the right of the General Offices, stretching away to the new station site on the west bank of the Schuylkill River. Parallel with "Pennsylvania Boulevard," and to its left, is shown Market Street as at present. The intervening strip of ground is the territory now occupied chiefly by the elevated tracks of the Pennsylvania Railroad and the so-called "Chinese Wall." These will all be removed and the site developed for commercial purposes, with office buildings and other structures as indicated in the drawing. The long diagonal thoroughfare is, of course, the Parkway, and is here represented as it will appear when fully completed, terminating at the Art Museum and the entrance to Fairmount Park.

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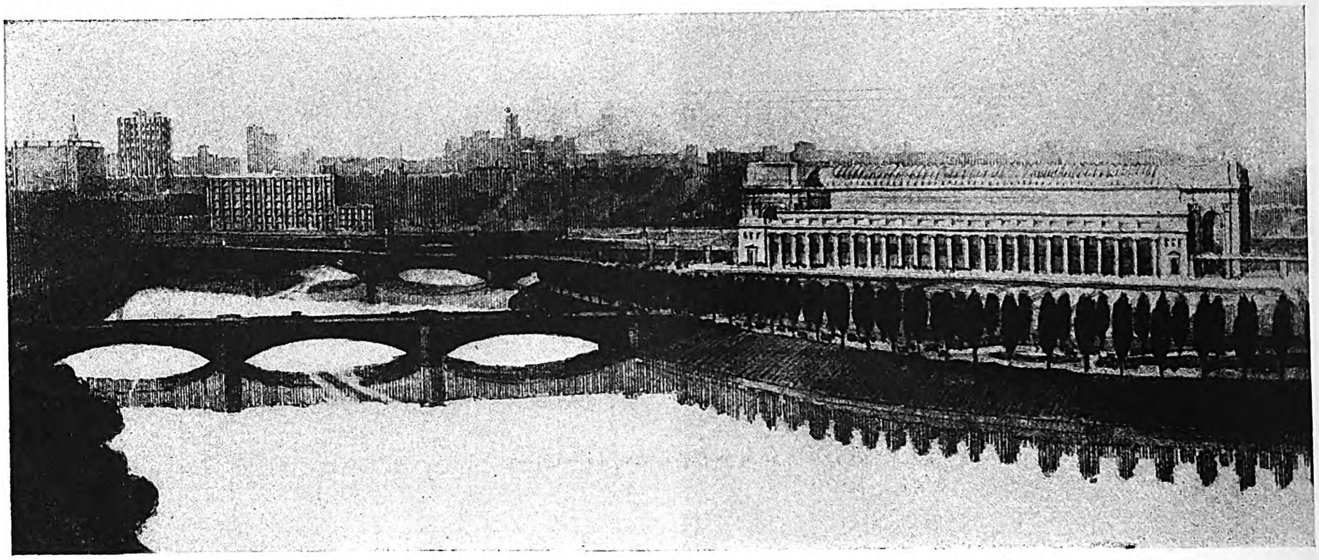
ter to relocate it from the west bank of the river to 30th Street, and enclose the tracks and platforms in the colonnaded section of the station in a manner similar to the treatment of the Pennsylvania Railroad suburban tracks and platforms on the north side. This relocation would clear Market Street of elevated railroad columns from the river to and beyond 30th Street.

Convenience to the passenger is one of the prime considerations in designing the West Philadelphia Station. Main entrances for passengers from taxicabs, busses, pleasure cars and street railway lines will be provided on three sides of the station—Market Street on the South, 30th Street on the West and West River Drive and Pennsylvania Boulevard on the East; the North side being retained for baggage rooms on the street level and under the suburban tracks and platforms, with elevators to the exclusive baggage platforms for the low-level through tracks and to the suburban platforms above. The vertical distance from the low-level platforms to the main waiting room floor on the street level of 18 feet, and from there to the suburban platforms and the P. R. T. platforms of about 20 feet, is, in each case, the minimum permissible for proper clearances.

The three bridges of the Pennsylvania over the river north of Market Street will be removed, and two



HOW NEW STATION AND BEAUTIFUL SCHUYLKILL RIVER WILL APPEAR, LOOKING SOUTH FROM ART MUSEUM

new bridges will be constructed, one to carry the P. R. R. suburban tracks on the north, and the other one for Pennsylvania Boulevard. Eventually, a new bridge over the Schuylkill may be constructed to replace the one now carrying the elevated railroad of the Philadelphia Rapid Transit Co., and also a new one at Market Street. These four bridges should be designed to harmonize with each other and with the new surroundings.

The north and south axis of the station, if extended, would pass directly through the Art Museum on the east bank of the river in Fairmount Park. Careful attention, therefore, will be given to the architectural treatment of the station, the Schuylkill River bridges and the West River Drive, because of the commanding location on this vista of a beautiful Schuylkill.

Express and Post Office Facilities

Several sites have been considered for a new City Post Office for general and rail delivery. There are three sites, one north of the passenger station and two south, the latter between Market and Chestnut or Chestnut and Walnut Streets, that would be directly over the low-level mail and baggage platforms. Such a location would be similar to that of the Post Office over the Pennsylvania tracks in New York City.

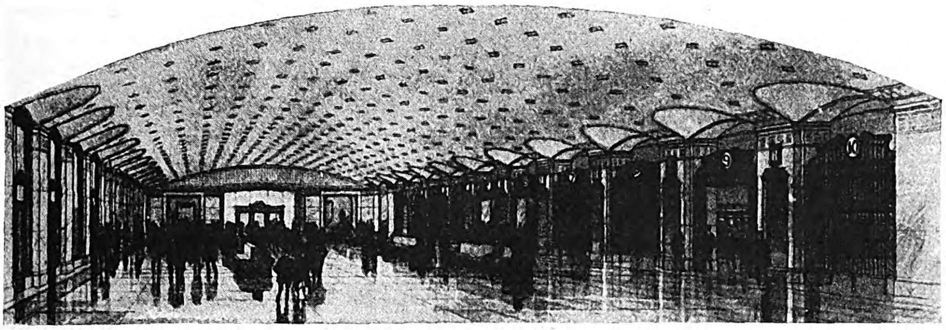
A site for a large building for the American Railway Express Co. has been selected at South Street. This site is particularly well adapted for rail and truck traffic. It is in a triangle of main rail routes, with tracks on the level of these rail routes for full length express trains, and is readily accessible to all tracks under the passenger station. Truck traffic to and from the express terminal will naturally use those streets adjacent to it, and, to a great extent, avoid streets to and from the center of the city adjacent to the passenger station. Trucking streets will surround this building above the track level, directly connecting with Walnut and South Streets.

The Underground Suburban Station

The new underground station at 15th Street, Pennsylvania Boulevard and the Parkway, for suburban trains, will be about 26 feet below the surface of the streets, with ramps and stairways for exits and entrances on the Parkway Plaza and on property that the Railroad Company now owns between the Boulevard and Market Street, some portions of which property the Railroad Company will continue to use in connection with the suburban station. There will also be access to the street from the west ends of the suburban platforms at 17th Street.

Convenient access will be provided from the station lobby to the underground pedestrian passageways now built, and those that it is hoped will be built by the City, over the subway lines and below the surface of the streets around City Hall, to Broad and Arch and Broad and Chestnut Streets, and possibly beyond these limits, so that P. R. R. passengers and those from the P. R. T. and City subways, and the public generally, can move freely underground beyond the congested street areas about City Hall without coming in contact with surface traffic. This idea was set forth by Mayor Kendrick in the early negotiations for the agreement of 1925. It has great possibilities for extension beyond those mentioned above, and would seem to be a natural and logical partial solution of the grave highway traffic problem of pedestrians crossing street surfaces densely used by automobiles and trucks, and a great convenience to the users of all present and future subway stations in this central section of the city.

This underground station will consist of 10 stub tracks, with provision for all necessary facilities for such a terminal. The main concourse will be very impressive, with a clear span of 70 feet in width, the



CONCOURSE—SUBURBAN STATION

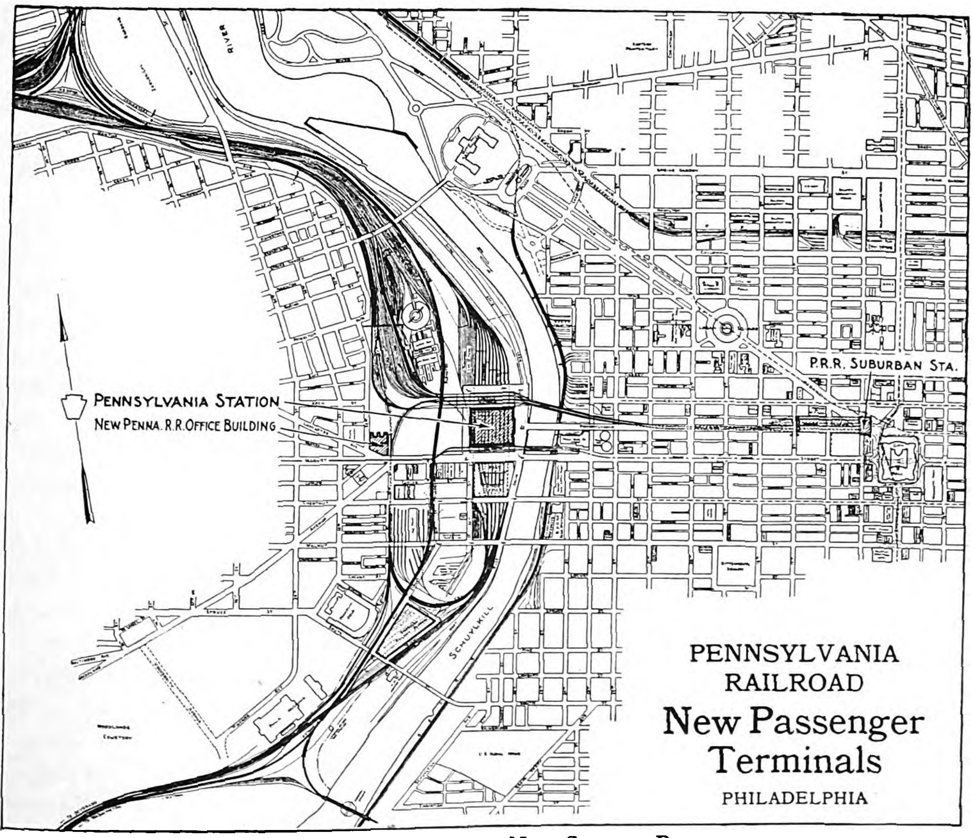
length being 250 feet. The curvature, grades and clearances in this station, and the subway leading thereto, are to be standard for all classes of electric rolling equipment.

When these improvements are completed, the Pennsylvania Railroad Co. will have three important stations in Philadelphia—first, the new main station on the Schuylkill in line with Pennsylvania Boulevard, through which trains from all divisions can be routed without reversing; second, the present North Philadelphia Station, through which all trains from New York to West Philadelphia, the West and South must pass; third, the new underground station at 15th Street and the Parkway, for suburban trains.

Function of Loop Tracks

Trains from the New York Division will use a new line on the west bank of the Schuylkill from the Zoological Gardens to the new Pennsylvania station. After making the station stop, the through trains will proceed to the South over a short stretch of new line to a junction with the present line of the Maryland Division and Octoraro Branch near the Commercial Museum in the vicinity of South Street; the trains for the West will use loop tracks in the form of a semicircle south of Walnut Street to connect with the present 32nd Street tunnel route, and thence over existing tracks to the West. There will be outlets from each end of the new station tracks to the New York Division; one direct over the new line paralleling the river, above described, to the Zoological Gardens, and the other via the loop, 32nd street tunnel and present connection to the New York Division near the "Zoo."

The loop, so-called, south of Walnut Street, is an inexpensive but most essential part of the new terminal plan; in fact, that loop, more than any other con-



GENERAL TRACK-LAYOUT OF NEW STATION PROJECT sideration, determined the location of the new Philadelphia station on the Schuylkill. Today we cannot route New York-Western trains to West Philadelphia and Broad Street Station except by changing power, reversing sets and sending the trains out the same way they come in. These loop tracks, which are on nearly a level grade and with a curvature of 9°, the same as the curvature on the Horse Shoe Curve on the Eastern slope of the Allegheny Mountains, will permit a train from New York to the West and vice-versa to make a continuous movement over the route through West Philadelphia Station.

New Office Building

While not a part of the agreement of 1925 with the City, there are two projects of great importance that are essential in making the Philadelphia plan effective. One is the first unit of the new office building for the officers and employes of the company, now nearing completion at 32nd and Market Street and Lancaster Avenue. This first unit, measuring 150'x250', fourteen stories in height, upon its completion early next year will provide offices for upwards of 5,000 P. R. R. employes, that number now being stationed in various offices, other than Broad Street Station, in the central sections of the City and in the old offices on Fourth Street. Many of them are located in buildings along Filbert Street that must be removed before the P. R. R. subway can be constructed under Pennsylvania Boulevard.

Electrification to Be Extended

The second project of importance is the electrification of the suburban lines. It will be necessary to have all suburban trains electrified so that they may use the subway and the new 15th Street Station under Pennsylvania Boulevard.

To relieve congestion in the handling of trains in Broad Street Station, the company electrified the Main Line to Paoli, a distance of 19.9 miles, in 1915. The electrified service now consists of 36 trains each way daily, or 72 in all.

In 1918, the Chestnut Hill Branch, 12 miles in length, was electrified, and in 1924 the Fort Washington Branch, 6.3 miles in length, beginning at Allen Lane Station on the Chestnut Hill branch; the service now consisting of 88 electrified trains, counting both directions.

On January 27, 1926, the Board authorized the electrification of the suburban service to Wilmington, a distance of 28.1 miles, and to West Chester via Media, a distance of 27.4 miles. Telegraph and telephone and certain signal lines between Philadelphia and Wilmington are being removed and replaced by cables in conduits underground; this work is practically completed.

The foundations for the cross-catenary poles and bridges are nearly all completed on the Wilmington line, and plans are ready to proceed on similar foundation work on the West Chester line.

There are now 138 passenger and baggage cars in use on the Paoli and Chestnut Hill lines. There will be 128 additional cars ready for the Wilmington-West Chester electrification of about 50 trains to Wilmington and 40 to West Chester. A growth in travel is anticipated similar to that which took place after the Paoli and Chestnut Hill electrification.

It is expected that the suburban service on these two lines will be operated electrically early in 1928. There yet remains the electrification of the Schuylkill Division to Norristown or Phoenixville, and the New York Division.

Magnitude of Train Service

While schedules vary each year and throughout the year, the scheduled revenue trains number 510 in and out of Broad Street Station on week days, 220 of which are classed as through or long-distance and 290 as suburban. In addition to this schedule, there are 77 trains that stop at North Philadelphia and 47 of these at West Philadelphia, but they do not enter Broad Street Station. The total number of train units, therefore, at the three stations is 587 daily. With the exception of 30, all of these trains now stop at West Philadelphia which shows the great importance of this location as a stop for nearly all trains.

On week days, the number of suburban passengers using Broad Street Station will average about 50,000, about one-half the number being inward and the other half outward. When the terminal plans are completed, these suburban passengers will use the underground station at 15th Street. A count was made to get an idea of how many of these passengers walked to destination and how many took surface cars, subway lines, taxicabs, etc. It was found that about 90% walked to destination.

Co-ordination with Transit Lines

Careful consideration was given to present and future transit and highway routes to reach the three main passenger stations. The Rapid Transit Company owns and operates the Market Street subway-elevated from the Delaware River to the 69th Street Terminal, where a number of suburban trolley lines terminate. It operates the Frankford elevated, giving high-speed through train service on two tracks from the 69th Street terminal to Frankford. There are two additional tracks in the Market Street subway from the west side of the Schuylkill to a loop around City Hall for many lines of surface cars from West Philadelphia. These routes are adjacent to the location of the new Pennsylvania Station in Market Street west of the river and to 15th Street station.

Plans have been adopted for East and West subways on Chestnut Street for surface cars, and on Walnut Street for highspeed trains, extending into West

Philadelphia by subway and elevated, crossing the river at or near Chestnut Street, with a station in close proximity to the Pennsylvania station. A subway on Arch Street, with connections west of the river, is a future possibility.

As stated, these five subway-elevated lines are, or will be, in close proximity to the Pennsylvania main station on the Schuylkill and to the underground station at 15th Street and the Parkway.

The City is now constructing the Broad Street subway from Spruce Street to Olney Avenue, with stations adjacent to the Pennsylvania station at 15th and the Parkway, and to its very important station at North Philadelphia. An arm of the Broad Street subway is to be constructed on Ridge Avenue to that section of the city at 8th, 9th, Market and Chestnut Streets to the Walnut Street subway that will provide continuous high-speed train service from North Broad Street to the westernmost section of West Philadelphia; therefore, the three Pennsylvania station locations would seem to be particularly well served by Rapid Transit subway lines for the convenience of the traveling public, whether for suburban trains, through trains or New York trains.

A Strategic Location

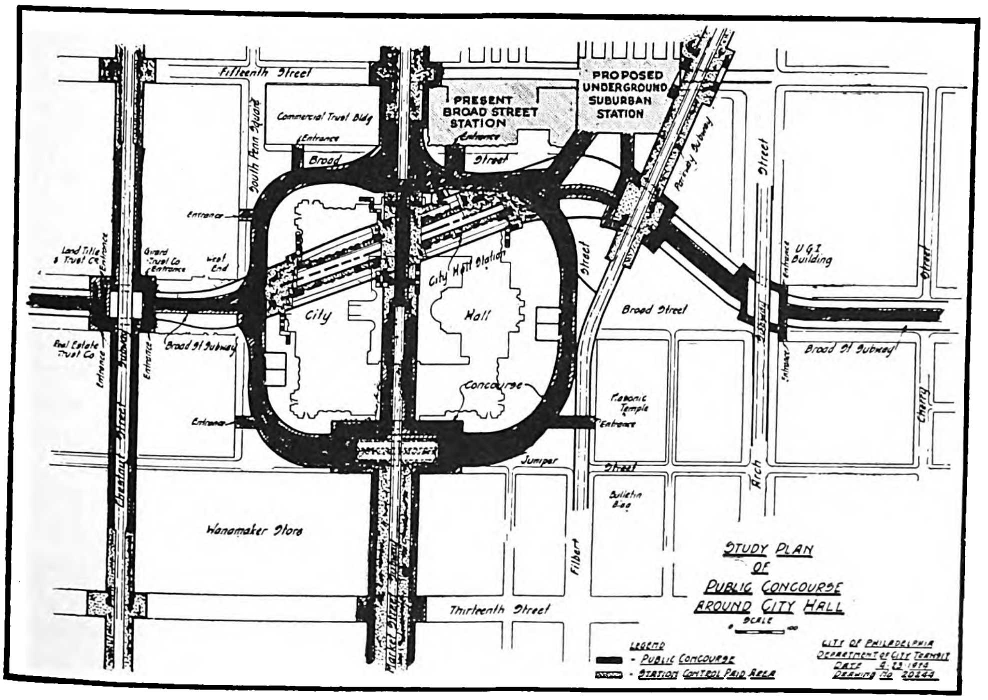
The West Philadelphia station, we believe, is particularly well located with respect to main arteries of highway travel; it is one mile from City Hall, and can be reached from that central section of the city by Walnut, Chestnut, Market, the new Pennsylvania Boulevard, Arch Street and the proposed river bridge at Powelton Avenue, the latter being a wide thoroughfare in West Philadelphia which will connect east of the river with thoroughfares direct to the new Delaware River suspension bridge, opened for travel July 1, 1926.

The new West River Drive, with its connecting highways, will provide a route from all of the southern sections of the city to the new station and to the north with the dense traffic routes through Fairmount Park, reaching out to the Main Line territory northwest of the city. Traffic over these routes will avoid the congested central city streets. It is proposed to provide wide driveways and loading and unloading space around the station for taxicabs, busses and automobiles.

The estimated cost of these improvements as prepared at the time the agreement was made with the City—and so far as plans have developed we have no reason to change—is $42,000,000 to the Railroad Company for railroad improvements, and $16,000,000 to the City for City improvements. These figures include to each party the proportionate cost of property acquired and to be acquired, but do not include to the company the cost of the West Philadelphia office building and suburban electrification, the former to be completed early in 1927, and the latter early in 1928.

City's Progress Fostered

In conclusion let us say that for many years the City of Philadelphia has desired and in fact demanded, the removal of the Filbert Street elevated railroad east of the Schuylkill, often referred to as the "Chinese Wall." City Administrations and various organizations have stressed the importance of clearing the banks of the Schuylkill, involving the removal of the


Fifteenth Street
PROPOSED UNDERGROUND SUBURBAN STATION
PRESENT BROAD STREET STATION
Entrance
Commercial Trust Bldg
Entrance
Broad
Street
South Penn Square
Parkway Subway
Street
Entrance
Land Title & Trust Co
Entrance
Guard Trust Co Entrance
West End
City Hall Station
City
Hall
Street
UGI Building
Entrance
Street
Broad Street
Real Estate Trust Co
Entrance
Subway
Entrance
Broad St Subway
Subway
Subway
Broad St Subway
Concourse
Masonic Temple
Entrance
Cherry
Entrance
Juniper
Street
Arch
Bulletin Bldg
Wanamaker Store
Chestnut Street
Market Street
Filbert
STUDY PLAN OF PUBLIC CONCOURSE AROUND CITY HALL
SCALE
Thirteenth Street
LEGEND
- Public Concourse
- Station Control Paid Area
CITY OF PHILADELPHIA
DEPARTMENT OF CITY TRANSIT
DATE 4.23.1926
DRAWING No 20244

CONVENIENCE OF THE SUBURBAN STATION SITE TO SUBWAYS AND PROPOSED PUBLIC UNDERGROUND CONCOURSE ABOUT CITY HALL IS HERE ILLUSTRATED

West Philadelphia Stock Yards, so that a West River Drive would be possible. Under the agreement with the Railroad company, the City will obtain all of these much desired and long wished-for improvements, and it will obtain more than that—a new highway from West Philadelphia to the heart of the city for a small cost in comparison with the cost of the Parkway, where many whole blocks of improved property were acquired; also a widening of 15th, 16th and 20th Streets will ensue. The result will be a diffusion of traffic rather than a greater concentration in the present greatly congested central section. It will also obtain a great increase in taxes because of the vast improvements to be made on property at the disposition of the railroad, and on all adjacent property from City Hall to well west of the terminal in West Philadelphia. The terminal plans make these things possible. Without concurrent action the cost and the physical difficulties to overcome would have made the improvements practically out of the question.

The Railroad obtains a new main station for Philadelphia, in which trains from all divisions can be through routed and avoid the delays and inconveniences to the Company and the public of handling through trains on stub tracks like Broad Street Station, a solution for which has received the thought and attention of officials for the last 20 years to my knowledge.

It will have two new stations of ample capacity to handle the increasing travel; they will replace Broad Street Station, opened in 1881 with eight tracks, now having sixteen, and the present West Philadelphia Station, opened in 1903, both existing stations and their tracks being inadequate at times for present day traffic—rail, vehicular and pedestrian.

All indications point to developments that will be greatly beneficial to both parties at interest, and made possible by the co-operation of railroad officials and a fearless, far-seeing City administration.

The Brunler Flame and Its Industrial Applications

By OSCAR BRUNLER, London, England

IT has long been the aim of engineers to obtain the full heating value of fuel by burning it in contact with the substance to be heated, with no intervening wall of metal, especially for steam raising.

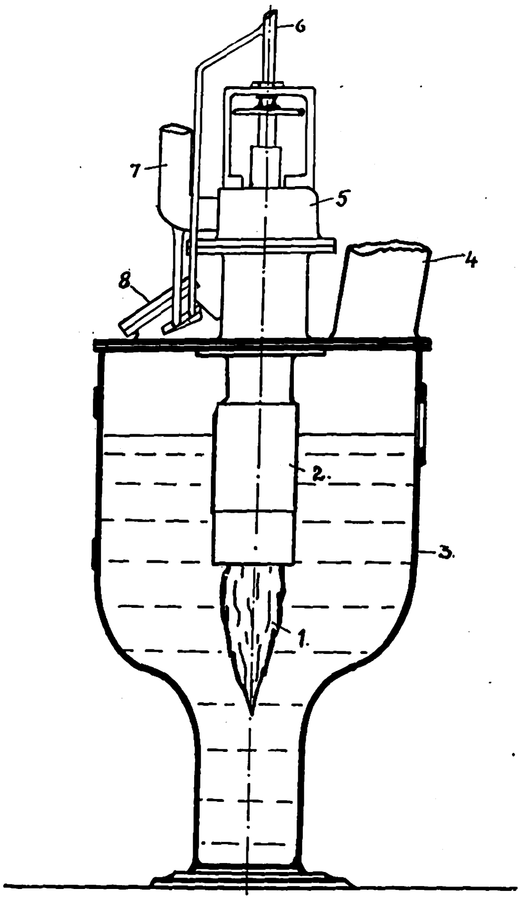
Forty years ago the late Oscar Brunler, Sr., started work on this subject, and after many difficulties succeeded in 1911 in making a flame burn in a satisfactory manner under water. Two years later this principle had been brought to the point where such a burner would work continuously. When the war broke out over 20 boilers had been ordered for various industries, but unfortunately these orders were not executed on account of the destruction of the factory in Belgium at the beginning of the war. After the war, work was resumed on the problem by the writer and it has now reached the stage of commercial utility for many purposes.

No question is more important for every power user and chemical manufacturer than the one of how to increase the thermal efficiency, and thus to reduce the costs for maintenance, of plants. Reducing repairs, saving of fuel, these are the points which must be considered first.

The steam engine, on account of the improvements effected in it during the last 100 years, is considered by many superior to Diesel engines for motive power. The fact, however, remains that the thermal efficiency of the Diesel engine is greater than that of steam plants. It is doubtful if the Diesel engine will ever take the place of the steam engine in years to come, but if the latter is to retain its supremacy over the oil engine, steam engine engineers must consider the vital question of how to convert a greater portion of the heat of the fuel into energy. How can this be accomplished? Eliminate first of all the heat losses in the boiler and, secondly, transfer the advantages of the oil engine to the steam engine. The best possible way to reduce the heat losses in the boiler is to do away with chimney, radiation losses, etc., and to burn the fire in immediate contact with the water in the boiler.

During the years of experimenting with the Brunler method there have been used liquid fuels of specific gravity between .8 and 1.2, and gases of various kind, and all these could be burnt without difficulty.

The accompanying sketch gives a diagrammatic representation of the means by which the result is achieved. The Flame (1), issues from Burner (2), below the surface of the water in the Steam Generator (3), in which there is produced a mixture of steam and gaseous products of combustion. The generator is provided with an outlet (4), for the steam-gas mixture which is led to a suitable receiver. The Regulating Valve for the mixture of fuel and air is shown at (5), the fuel being supplied by pipe (6), and air by pipe (7). The fuel is mixed with the correct quan-



THE BRUNLER FLAME

tity of combustion air in the regulating valve and admitted to the burner under a pressure slightly above the working pressure of the generator. By means of a superheater, which is designed on the same principle as the burner in the steam generator, and whose flame burns in the steam receiver, the steam can be easily superheated to any required degree. The size of the flame and consequently the quantity of steam can be increased or decreased immediately by turning the regulating valve, thus allowing only a small, or the full, quantity of combustible mixture to flow to the burner.

The steam-gas mixture consists of the same gases which do the work in gas and oil engines, the only difference being that in these engines the amount of steam in the combustion gases is much less. It is well to keep in mind that a steam-gas mixture has an extremely high power of expansion, which is due to its low specific heat and which consequently may be worked with the highest efficiency.

The following figures give the power which is obtained by burning one kilogram of oil. 1 kg. of oil requires 14 cubicmeters of air for complete combustion in water. 1 kg. of oil requires $14 \times 1.22 = 17$ kg. of air. 1 kg. of oil produces 15 kg. of steam + 18 kg. of combustion gases, totalling 33 kg. of steam-gas mixture at 170 lb. per square inch pressure and superheated to 700° Fahrenheit. 5 kg. of steamgas produces one horse power hour. Hence 33 kg. of steamgas is equivalent to $33 \div 5 = 6.6$ HP. Hr. The compression of 14 cubicmeters of air from 0 to 172 lb. per square inch pressure requires, in a good compressor, 2.35 horse power hour, as 6.6 HP. Hr. were produced by the steam-gas mixture of 1 kg. of oil burnt in water, 2.35 HP. of this was required for the compression of the air, leaving a net horse power of $6.6 - 2.35 = 4.2$ HP. per kg. of oil burnt.

It will be obvious that such a system possesses many advantages and has a wide field of application. When used as a steam generator the following are some of the advantages offered, in addition to a very largely increased thermal efficiency. There will be no smoke and no chimney will be required. There is no incrustation, no matter what type of feed-water is used, and softening of the water is completely unnecessary. A generator about 3 ft. in diameter and 5 ft. high will evaporate 5,000 lbs. of water per hour, and steam can be raised in ten minutes from cold. It is possible to make these boilers for any desired working pressure. The steam-gas mixture produced, which consists of approximately 50 per cent. of steam (by weight), with 14 per cent. of CO^2 and 36 per cent. of nitrogen, can be used in reciprocating engines or turbines, no condenser being necessary to obtain the same temperature drop as is obtained in modern condensing engines. This has an important bearing on the problem of large power stations with an inadequate supply of condenser cooling water.

In addition to steam-raising the Brunler Flame is of great use as an evaporator.

Practically any chemical solution can be concentrated by this means; and since the concentration can be carried out under high pressure, it is possible to use the steam produced for power purposes. This naturally reduces the cost of concentration to a very low figure.

Sewage sludge can be concentrated by this means, and the steam produced is available for power. Similarly the concentration of chemical waste liquors that at present cannot be made use of owing to the excessive cost of removing the water, becomes a paying proposition when the Brunler Flame is used. In such cases the steam required for power and heating in the works is evaporated from waste liquor instead of fresh water, and the recovered product is won without any expenditure for fuel.

An important point with regard to the use of the Brunler Flame in Chemical Industry is the fact, that if it is worked at atmospheric pressure, the steam-gas mixture is produced at a temperature of 80° C., owing to the partial pressure of the steam and gases forming the mixture, so that the principle is frequently applicable without difficulty to processes that at present have to be performed under a vacuum.

Grinding*

A Precision Method for Quantity Production

"GRINDING," like many another English word, has more than one signification. To the miller it means making flour of grain. To power and metallurgical engineers it means reducing coal or ore to powder as a step in a process. To machinists it meant not so many years ago giving metal parts a refined finish by removing a little surface metal with a small thin abrasive wheel in a light machine.

In 1886, Charles H. Norton, born at Plainville, Connecticut, in 1851, began putting a new meaning into "grinding." Progress was slow. In 1895, Niagara, harnessed, began to supply electric current in unprecedented quantity at low price. About this time, Charles B. Jacobs invented a new abrasive, known by the trademark "Alundum." Soon Aldus C. Higgins followed with the water-cooled electric furnace for producing alundum abrasive in quantity, in the works of a company bearing the name of a Norton of another tribe. C. H. Norton now had a strong, effective cutting medium for his grinding machines.

Norton was trained at the Seth Thomas Clock Works in making machines for indicating the passage of time. He was impressed deeply with the value and the never failing exactness of time. Later, he noted the great amount of time and highly paid labor then required for precision grinding. Realizing more and more the usefulness of precision grinding in modern machine production, he set out to reduce its cost. About that time, new special steels were making feasible very deep cuts with metal-working tools and were absorbing interest generally. Norton, however, appears to have been first to perceive that the electric furnace abrasive wheel, mounted in a heavy machine, might remove metal in small particles as rapidly as the special-steel cutting tools. This conception started him on his experimentation.

At first, "practical" machinists thought Norton's ideas very impractical. Fortunately, however, there were enough courage and money to back his investigations and demonstrations. During the past two decades, a remarkable evolution has been wrought, a new mechanical process has been brought into wide use.

Twenty-five years ago the grinding machine was a light, low-powered tool, polishing surfaces and occasionally doing accurate sizing to a limit of one-thousandth of an inch, at great cost. Today, a heavy, high-powered production tool with a precision of one four-thousandth of an inch in commercial manufacturing, it has become a big factor in low-cost and high-rate production of automobiles, locomotives, machine tools, cash registers, linotypes, monotypes, adding machines, typewriters, agricultural machinery, machine tools, armament and many other metal objects.

Norton's fundamental idea was that a modern abrasive wheel set in a sturdy machine and driven by a lot of power could cut metal rapidly, accurately and cheaply in spite of high first cost for equipment. Old grinding machines used a fraction of a horse-power. He proposed applying at least 15 horse-power in each machine. The old wheels removed about one-sixteenth of a cubic inch of metal per minute. Grinding machines now remove from two to six cubic inches and in rare operations as much as twelve cubic inches each minute. Frequently, when cutting as much as three to four cubic inches of metal in a minute, grinding machines leave the work sufficiently accurate and well finished to need no further refinement. From being a method of securing refinement at great cost, grinding has become one of the cheapest methods of production for cylindrical objects of metal with finished surfaces. Flat surfaces also can be produced very accurately.

Novel features were introduced for getting great accuracy without the highly skilled machinist. Mechanics of ordinary training can obtain the desired results. Modern quantity production demands interchangeability of parts. Each part must be made so accurately as to size and shape that any of them can be used without selection in putting the mechanisms together. The new grinding machines made it possible to secure exact size on repetitive work in unlimited quantities.

The old conception of precision and delicate adjustment was embodied in light, small, beautifully made mechanisms. Norton made massive machines with heavy operating parts capable of being moved a distance so small that a line of that width could not be seen with the naked eye. That the movement can be made repeatedly with absolute dependability has often been proved by making four adjustments of twenty-five one-hundred-thousandths of an inch, always arriving exactly on the test line.

By combining massiveness and large power with great precision and utilizing the superior new abrasives, Norton developed a new art of cutting metal which has contributed largely to present-day economy and efficiency of many machines in daily use on farm, highway and railroad, and in factory, office and home.

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*Engineering Foundation Research Narrative. No. 118. Contributed on request by Aldus C. Higgins, Member A. S. M. E.

"Vital Changes in Heating Resulting from Research"[*]

By THORNTON LEWIS

President, York Heating and Ventilating Co.

THERE have been some very vital changes in the heating industry; in fact, I would say more vital than in any other branch of engineering in the past five or seven years. The primary reason for this has been that in the early days heating was largely in the hands of plumbers and people who lived mainly by using their hands to install equipment which would give us heat. Only recently science has taken hold of heating and begun developing those things which pertain to it, including ventilation. It has only been in the last seven years, or since the war, that a great deal of research has been done along the lines of heating, but in that short time many things have been found out and discovered that were not known before; and at this moment, the whole art of heating and ventilating is in a process of change. Of course, these things move rather slowly, but being in that line of endeavor, I have been surprised at the speed with which the result of research is being put into practice. It was only seven years ago that the American Society of Heating and Ventilating Engineers did what no other national society had done or has done since, which was to establish and maintain a research laboratory for the determination of fundamental facts relating to heating and ventilating, and giving its findings to the public. It is non-commercial in every respect. It is located at Pittsburgh, Pa. One of our fellow members, Mr. H. P. Gant, is National Chairman of this Research Committee.

I will mention briefly one or two things that have been developed. About twenty years ago we started to use the B. T. U. method of calculating heat losses—that is, a certain surface would radiate so many B. T. U.'s per degree of difference in temperature. I don't think anybody knows where all the factors came from that are in general use. None of them are absolutely accurate—most of them are good guesses that have worked out fairly well. The laboratory has developed a heat meter which can be placed on any wall. The transfer of heat through that wall can actually be measured. At this time, there is in process of being tabulated, the heat losses on ordinary building material, so that within another year or so, we will have constants for heat losses that will be accurate and that will be based on scientific data. We can then calculate very closely the heat loss of various structures. The ordinary method of doing that today is to calculate the losses from whatever constants are available and then add 10% to 25% as a factor of safety. That may seem very large, but after all when you stop to think that in structural work 500% is generally added, it is not so bad.

In addition to the research work done at Pittsburgh, there has been a great deal done by manufacturers and by individuals. Many people have cooperated in another very forward-moving development, and that is to find out in what condition of heat, of moisture, and of air movement, the human being is most healthy and comfortable. We have all thought and probably have had some basis for it, that if we heated a building to a temperature of about 70 degrees, dry bulb, we were comfortable. We used the dry bulb thermometer as the entire judge of our comfort, and now we know that that is not a judge of comfort. Everyone today probably experiences a sense of discomfort. Perhaps, you feel this room is entirely too warm. It is not so much the heat but as the old bromide goes—the humidity. If we could reduce the humidity in this room very quickly, you would all probably feel chilly even though the temperature remained the same.

The Laboratory at Pittsburgh has determined what is the effective temperature; it isn't the dry bulb, or the wet bulb, or the air current, but a combination of all three that produces a certain degree of comfort. You might think that is a very nice theoretical determination, but where is its practical value? Of course, we all think immediately of health, and that is one of the most important uses of it, for in the course of time when we come to realize that it pays us just as well to spend a little money on the human being as it does on the manufactured article, we will probably plan all our buildings and maintain them at the point of greatest comfort, from the standpoint of temperature, humidity and air motion. One of the other practical applications that occurs to me is in a steel mill or any industry where temperatures higher than normal have to be maintained on account of the processes of manufacture. By the use of the comfort chart which has been produced by the A. S. H. & V. E. Research Laboratory, you can find out what relative humidity and what air motion will give those workers, who have to be in this high dry bulb temperature, more comfort. The research by the manufacturers has largely been along the lines of heating rather than ventilating. They attempt, of course, to find out how they can deliver a thousand, or any quantity, of B. T. U. for less dollars, both as to first cost and as to operating cost.

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[*] Address before the Engineers Club, November 9, 1926.

In our research work, we haven't found anything so fundamental that we are going to change the fact that there are roughly 960 B. T. U.'s as latent heat in one pound of steam at 5 pounds pressure. We are not going to change any fundamental things like that with the facts found out by research; but we do change such vital things as this: Formerly it took about 4 square feet of radiation to give out those 960 B. T. U.'s, but now we know that we can do that with less than one square foot, and that is a great economic saving. And here are some of the observations along that line. We have in this room a radiator made of cast iron—a common form used for heating. It probably took two or four men to put that radiator in place. We could, with some of the new developments in heating, which makes use of less prime surface and a good deal of extended surface, have one man carry that radiator in here and place it in position, with the economic saving which that makes when multiplied on big operations. With the radiator here, how do we get heat into this room? Let's stop and go back to a few fundamental principles. The steam is turned on, the surface of the radiator becomes warm and heats the air around it; makes it more buoyant, and the warm, buoyant air rises to the ceiling, and as it rises colder air flows in and takes its place around the radiator. We are not flies, we are not interested in the temperature up at the ceiling. Where we want the heat is right down here where our feet get cold, and that is a subject that we have inquired into a bit. How can we keep that heat from rising and banking up above, and finally radiating its heat from the hot air above to the cold air below; for that is the way we get the heat down near the floor? And most of you are familiar with the fact that we use air as an insulator, because it is a poor transmitter of heat. Research has found out a few things about that; found out that if you obstruct that buoyant air and make it come out more horizontally, naturally, it is going to mix with the colder air and communicate its heat to it, and not bank so much heat up above. How can we do that? Well, we can do it inefficiently by putting a baffle over the top of the radiator. Of course, a more efficient way would be by mechanical means which would control the hot air. We find that an ordinary radiator, or coils, installed overhead has been a very common practice, and a very bad one. Also that the difference in temperature—and you who are interested in this subject, might try it in your homes sometimes—between the floor and ceiling is approximately two degrees per foot of height. In other words, if you have a room ten feet high and maintain 60° at the floor line, you will have about 80° at the ceiling. Let's stop and think what that means where we run up to 60 or 70 feet high, or even 25 feet; and then let us stop and think of another fact, that the heat loss to the outside is dependent not only upon the material of which the roof, or walls, or surfaces are made, but upon the difference in temperature between the inside and the outside. Now you can see right away that if we overheat the top of our buildings 25° or more, we are going to have just that much more heat lost to the outside. A good many investigators have made a general statement, and it is only a general statement, that it is possible to save from 15% to 25% of our fuel bills by overcoming that condition. How can we do it? Well, suppose we take one-sixth of this radiator, and take the other five-sixths and throw it away, and suppose we put a casing around it and with a fan mechanically draw air over its surface. We get just as much heat as we got with the original radiator six times its size, because we have increased the effectiveness by pulling air at high velocity over its surface; and then if we take the same mechanical means used to draw the air over the surface and blow the warm air, which is buoyant, out in a horizontal direction, just over the headline, approximately 8 or 10 feet above the floor, we can control that buoyant air and hold it down nearer the breathing zone where we want to use it, and not let it ascend immediately to the ceiling due to its own buoyancy. Now by holding the stream of air horizontally for an appreciable length of time, we give it a chance to radiate its heat to the surrounding air, which is in the breathing area where we want it, and in that way we can hold down the temperature variation to about one degree rise per foot of height.

The difference between the two methods is quite a saving in your coal pile. To illustrate: If we had a number of paper balloons here and this radiator had steam in it and we held those paper balloons over the radiator and filled them with hot air, we can all picture what would happen to them. They would go up, and if we did that successfully, we would have the top of the room filled up with paper balloons; but if, instead of that, we had a fan for creating high air velocity and filled these balloons and put them in front of the fan it would blow the balloons out and keep them travelling horizontally until at least some of the heat had been dissipated. That is the principle of using mechanical means to overcome the difference in temperature.

There have been a number of changes in the equipment we use for creating heat, primarily, that is in boilers, in getting away a great deal from the cast iron boiler to the steel welded boiler. There are still a great many cast iron boilers used, but what I am trying to suggest is that research has shown up many changes in that particular phase of the heating industry. We are coming to use more and more extended surfaces in boilers as well as in radiation.

The place in which we are primarily interested, of course, is our home. My remarks about mechanically controlling this buoyant air applies primarily to large buildings or large rooms, such as industrial plants, gymnasiums, etc.; in the home it is hardly feasible, or desirable, to put in any more mechanical apparatus. We have almost enough today with our electric refrigerators, vacuum cleaners, and blowers on our oil heaters; so I doubt if the average American wants any more equipment in his home if he can help it; but he would like to save when it comes to purchasing or operating heating equipment. How is he going to get away from the old cast iron radiation? Some of the manufacturers today have already answered that question, and while I am not going to speak of any particular equipment, there are one or two things in connection with some of the equipment on the market that I think will be of interest. One manufacturer has brought out a radiator consisting of copper fins, the prime surface and core is made of an aluminum alloy and made in a peculiar shape, and certainly shows that a good deal of research has been done in order to get that particular shape. This radiator, the particular arrangement of it, is just as efficient as any cast iron radiator, but it has the advantage of being very small. About 4 inches in width and the length can be made to suit. That can be placed in between your 2x4 studding with a little grill at the top and one at the bottom, and do away with the unsightly space-taking radiator in the room; and the cold air off the floor will move through the radiator and the warm air will come out at the top and you get your circulation.

The reason I mention the particular shape of this prime surface is because there is no danger from freezing. This particular radiator has been developed so that it can be frozen absolutely, then thawed out and put under 150 lbs. pressure and remain absolutely tight, all due to the shape of the prime surface, which as the water freezes and expands, the shape of the prime surface changes and gives more area. That certainly is a very nice development of research. There are other manufacturers making a surface of the light weight type that will take up less room, cost less and be less expensive to install, even though they are placed right in the room.

All of these changes have come about through what is called finned surface radiation. We have found that we don't need as much surface as prime surface. One of the largest manufacturers of cast iron radiators in this country has had an engineer—a very eminent scientist from abroad—who has been working for two or three years on this question of heating, particularly as applied to small rooms in dwellings; and as a result of some of the preliminary things he has found that changing the shape of radiators, changing their arrangements with baffles over the top, you can save at least 15% of the steam and produce the same temperature in the effective zone which is within about 6 or 7 feet from the floor. Of course, the way that saving is accomplished is by lowering the temperature above, and, therefore, not wasting as much heat where it does no good. We have found in a great many cases with indirect systems we were handling entirely too much air, and that there is a very definite trend now—and like most pendulums, this one has swung clear to the other side—there is a demand in several states for the elimination of all laws relating to ventilation in schools, saying that the old open window method after all is the best method of taking care of the heating and ventilating of the rooms in which our children go to school. I think that doesn't appeal to many engineers. We do know that the outside air gives us a feeling of exhilaration which stimulates certain nerve centers, but we also know that in a closed room, if we open a window it is very easy to create a draft, and that that method of ventilating a room might be termed "uncontrolled ventilation." We are at the whim of the winds. While with a mechanical system, by displacing a definite amount of air, we can then introduce the quantity of air and at whatever temperature and condition of humidity we decide is best. After all it is not a question for the engineer to exactly determine what is the best condition for the human body—that's a job for the doctors; but the doctors have been so little interested in the subject, that the engineer has had to take it over, more or less. The demand on the part of some individuals for the elimination of all laws in regard to ventilation in schools I think is one of the most pernicious things that has ever arisen in this country. The standards of ventilation and of heating, which have been adopted by the various States, have been slowly built up by hard work in order to protect the health of children and of the public in general. I do not mean to say that the standards which we have today are necessarily right, but certainly before we tear down standards which have been built upon experience, we should first know what is the right standard, and go to that, and not simply tear the whole building down and say, "We don't need any standard." The open window ventilation, as I mentioned before, is dependent purely upon the whim of the wind. It is like the old sailing ship, it moved when the wind moved, and I think very few of us would want to go back from our steam-driven palaces on the ocean to the old sailing ships

All engineers working in this particular field are opposed to tearing down standards of ventilation which have been slowly built up by hard work, and going back to some thoughtless propaganda.

I feel that we as engineers should probably be a little quicker to adopt some of the things which science and research and progress have shown are based on sound principles. We should not be quick to adopt those things which are not based on sound principles, but certainly we should not lay aside the discoveries of research, and I think that applies to the field of heating and ventilating as well as any other field.

We have made a lot of progress in the last ten years in heating and ventilating, and the next ten years we ought to make five times as much. I am optimistic about it and I believe you all are. I feel the same way about all engineering.

The Power Engineer*

By GEORGE A. ORROK

Consulting Engineer, New York City

An early philosopher, commenting on the problem of life has stated that the struggle for existence is primarily a struggle for food and shelter, and one of our later writers, Mr. Spurrell, defines civilization as "the mode of life in a territory which is maintaining a larger population than could live on the land if people were not organized to develop its resources." While we may not entirely agree with Mr. Spurrell's definition, it is certain that in every case where civilization—even of the crudest kind—has existed, the first part of his statement is true.

Early Power Development

It has been said that man is the only tool-making animal. His earlier attempts have been shown us in the remains of the STONE AGE and consist largely of weapons, although he early developed the principle of the lever and the pulley. His attempts to secure additional power or additional ability to obtain food and shelter were also manifested in the domestication of animals. The use of these animals as beasts of burden increased his man power to a considerable extent and when, in the course of ages, he discovered how to build rafts and boats, and to use the force of the wind to propel them, a very large step in progress had been taken. However, taking together all of the increase in power which had been made up to the Christian era, it is probable that the use of tools and engines had added only possibly about 50% to his unaided work.

From the very earliest times those who possessed the best arms and the strongest physique, had obtained additional power by enslaving their neighbors. It is stated that the Spartans had as many as six slaves per capita, and the Spartan civilization was the highest known at that time. The Roman Empire depended entirely upon its slaves to do work. Between the time of the reign of Augustus and the breaking up of the Roman Empire the population of Europe decreased at least 50%.

Modern Power Development

But the Renaissance was at hand. After hundreds of years of eclipse the inventive mind of man turned more to mechanical devices. Printing was invented, books became common, schools were founded and the knowledge of the development and use of power as disseminated amongst the peoples. Savery, Worcester, Papin and Newcomen, with the utilization of the work of steam so changed the face of nature that each man's work was augmented by at least 50%, and a few generations later, Watt, Awkright, Trevethick, Stephenson and Fulton, with the improvement of the steam engine, and its adaptation to the generation of power and means of transportation, soon made each man's labor three times as productive. Later and within our memory came Faraday, Edison and Westinghouse, and man's output was doubled again. The Central Station had been germinating since about 1830 and became a fact in 1880. Meanwhile the slave population had practically disappeared from the earth, being replaced by what soon became our modern production system.

Increase in Use of Power per Capita

The use of power augmented on the compound interest rule as the years went by, so that by 1880 we may say that no less than 2½ H. P. per capita was used in the United States, or, that each man's labor had been multiplied more than 15 times. Today our means of transportation have been enormously increased. Within the last 20 years there have been over 500,000,000 H. P. added to our transportation facilities in the automobile. It is estimated that as of 1920 the use of power in the United States amounted to 7½ H.P. per capita, or nearly 45 man-power per head of population. While this is true in the United States, other countries have not been as fortunate in the use of power, and Great Britain, with about 4½ H.P. per head of population stands second on the list. Other countries depend more on the work of man's hands as in the past. The worst example of this, and a warning to us, is the case of Russia where considerably less than ½ H.P. per head of population was in use.

Probable Future Increase in Use of Power

Certain estimates have been made as to the probable increase in the use of power in the next few years. The Superpower Report estimated an increase of 160% in ten years. Other figures have been more optimistic, but we know that the power and light business has been increasing at a uniform rate, for about 25 years, equalling 10% compounded annually. Transportation has increased at a much faster rate than this, but these figures without doubt do not entirely give a true picture of what is going on because many mechanical devices now in use, for the multiplication of man's power have not been covered in the various surveys.

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*Address before the Engineers Club, May 18, 1926.

Power as a Big Field for the Engineer

I have sketched very rapidly what may be called the "history of civilization" for perhaps something like a half million years. During all but about a century of this time the growth of the use of power has been exceedingly slow, while in the last century the curve has taken almost a perpendicular trend until in the last 100 years the use of power is at least 16 or 18 times more than it was at the beginning of the century. It is now believed that our utilization of power, and control of our natural resources, will go on increasing, not perhaps at the same rate as during the last century, but at least in a very generous relation, and it therefore very early appealed to the engineering profession as the one big field for the engineer. In fact, almost all engineers have been more or less concerned with the use and development of power.

Economies in Use of Fuel

Let us for a moment consider the economies in the use of fuel which have been made since the first use of heat for the generation of power. Savery's engine, built about the year 1660, used 100 pounds of coal per H.P. and gave a duty around 4,000,000 ft. lbs. per 100 lbs. of coal. Newcomen's engine of 1750 used 22.1 lbs. of coal per H.P. and developed a duty of 19,000,000 ft. lbs. per 100 lbs. of coal. James Watt's improvements lowered the coal rate to 3.26 lbs. per H.P. and raised the duty to 68,000,000 ft. lbs. of work. The Wildwood pumping engine of Bruno Nordberg's used 1.2 lbs. of coal per H. P. and gave a duty of nearly 200,000,000 ft. lbs. per hundred pounds of coal.

Today our Central Stations run on around ¾ of a lb. of coal per H.P. with a duty exceeding 300,000,000 ft. lbs. of work per 100 lbs. of coal. Here we see an increase of over 99% in economy in the use of fuel in the three centuries which have elapsed since Savery built his first machine.

Reduction in Use of Fuel per K.W. Hour

As electricity has played a large part in the power development of our generation, it may be well to translate these figures into the common electrical unit we all know so well, extending the tally to include the very latest word on economy of power generated. Savery's engine used 1,880,000 B. T. U. in the fuel per k.w. hour and Newcomen's engine used 416,000 B. T. U. per k.w. hour. Watt's best record is 61,000 B. T. U. per k.w. hour. The Wildwood pumping engine used 19,200 B. T. U. per k. w. hour, while our Central Station records are usually given over a year's time and range from 30,000 B. T. U. in 1900 down to 18,000 B. T. U. in 1920, with short time tests as low as 17,000 B. T. U. Today we have at least three power stations in this country running on 14,000 B. T. U. per k.w. hour over a period.

Losses Still Too Great

But the losses are still much too great. Even in the best tests just quoted, the thermal efficiency has rarely exceeded 24%. The mercury turbine at Hartford, however, may increase this so that efficiencies of 30%, or even higher, may soon be within our reach.

In a paper presented before the A. S. M. E. in December, 1899: "The Steam Engine at the End of the 19th Century," Professor Robert H. Thurston, of Cornell, analyzed the record of the Wildwood engine, and in that paper called attention to the means its designer, Bruno V. Nordberg, used to attain the high economy. Thurston traced the use of the regenerative cycle from John Bourne through Cotteril, Weir and Kirkaldy to Nordberg, and in the discussion J. B. Stanwood, of Cincinnati, presented a diagram showing how near a heat engine, using steam as the working fluid, may approximate to the Carnot cycle.

The Carnot cycle has a rectangular diagram in the temperature entropy field, while the water line slopes upward from left to right and the saturation line downward from left to right, making a diagram narrow at the top and wide at the bottom. Now if it were possible to take heat from the expansion side of the diagram and use it in heating the water, the trick would be done, and the entropy diagram would be a parallelogram but not a rectangle. The area of the diagram however, the work done, would be the same as the Carnot cycle of equal width and height. This result Nordberg nearly secured by a succession of feed water heaters in which he transferred heat according to theory. Could he have multiplied the number of heaters without losses, almost perfect results would have been obtained, but even the four heaters were found too many in practice, and the engine is now superseded.

The turbine offers a much better field for this kind of saving, and Ferranti in 1906 proposed the use of the regenerative reheat cycle. The designer, however, must keep in mind the commercial aspects of the problem and remember that complications invariably add radiation and pressure losses, which often lose more than the theoretical gain. However, this device is being adopted and more than 2,500,000 k.w. of generating apparatus is using this device in various degrees at the present time.

Raising Limits of Temperature and Pressure

We have also considered raising the limits of temperature and pressure, and 1200 pounds pressure is now being used in this country. Temperatures higher than 800-900° are being talked about, and in the oil industry 1100° is being used. Or the binary vapor plan may be used in Emmett's mercury vapor-steam turbine, in which he secures a greater temperature range with less pressure range. It also appears, however, that we still have much to do in the stopping of heat leaks and the saving of losses rather than perhaps by any possible extension of the working limits. And our true criterion is always the heat in the fuel per unit of useful work.

Load Factor Very Low

Taking, in round numbers, the 900,000,000 H.P. used in the United States, it is quite evident that the load factor is very low, since our coal, oil and water power used in power production is equivalent to not over 300,000,000 tons and may be considerably less. It, therefore, appears that the average use of that power is under 500 hours per year, a load factor of around 6% with an average of more than 5 lbs. of coal per horsepower. Now the best work today is ¾ lbs. per horsepower, and it is the work of the power engineer to improve the present condition and prevent this enormous waste.

Is there another field of such magnitude with so many ramifications and side lines, so many chances for service to mankind, such an opportunity for creative work for the advancement of civilization and the benefit of man? It has been said that he who makes two blades of grass grow where one grew before is a benefactor of our race, but what may be said of him who produces 2 H.P. of useful work from the same fuel and machinery that formerly produced 1 H.P. Each H.P. is equivalent to 6½ pairs of able hands when properly applied, and today we have in machinery the equivalent of 3,000,000,000 of machine slaves to relieve us from burdensome toil.

Kipling's dictum in "The Night Mail" that "Transportation is Civilization" is at least partly true since a large part of our use of power comes under this category. Light and heat, agricultural machinery, the mines, mills and manufactories, and the building trades help to complete the total.

The civil engineer uses power to prepare his materials, to erect his structures, and to operate them when completed. The mechanical engineer uses power everywhere, as does the electrical engineer, while the mining engineer is no less dependent on power for most of his work. The chemical engineer needs supplies of it in his work and even the sanitary engineer must use it in his water supply, sewerage and sanitation schemes. The metallurgical engineer must make and use large blocks of power.

As I listened a few months ago to Judge Gary making his annual address to the Iron and Steel Institute, I remembered a picture hanging in his office in New York. This picture is a photograph of a Basuto blast furnace in South Africa, a hand power blast furnace employing eight men. The bellows men work in two hour shifts and there are four sets of them, or 35 men. The furnace after 24 hours in blast produces something over 100 lbs. of poor iron and makes two blooms a week—just about one pound of iron per man per day. On the opposite wall is a photograph of the record furnace 100 ft. high, 28 ft. bosh, making on the average 600 to 800 tons of iron per day (the record is nearly 900) with about 60 men, or 20 on a shift, 10 tons, 20,000 lbs., of iron per day per man. The Basuto picture was taken not over 10 years ago. This is the work of the Power Engineer.

My own great grandfather journeying from Boston to Petersburg, Virginia, in 1798, took over six weeks to make the journey, and he was in a hurry. I came to Boston from Washington the other day in 12 hours, almost as wonderful a performance as the Pittsburgh furnace.

Less than sixty years ago my house was lighted with candles, homemade—I have the candle molds now, while today I have 100 watt gas-filled tungsten lights costing .7 of a cent per hour. An equivalent light in tallow candles made by hand would cost nearly 20 hours work of a woman, worth, say, $5.00.

We could multiply these illustrations indefinitely with results in varying proportion, but I have said enough to show you the vastness of the field and the need of the Power Engineer. The curse of the Garden of Eden "Thou shalt earn thy bread in the sweat of thy brow" has been lifted, and the Power Engineer will not rest in his endeavors until it has been entirely removed and forgotten.

Russia During the World War*

By JOHN F. STEVENS

Consulting Engineer, Southern Pines, N. C.

I WAS in Russia awhile, which includes Siberia, and I was all over the Far East for about six years. I suppose many of you know why my Commission went, and that it was at the request of the Provisional Government, to assist it in transportation matters; and as a preliminary, I want to say there were a number of names under discussion by the "powers that were" in Washington; among others, myself. They kept whittling them down until they got down to a very few and finally my name came up. Well, some one said, "Yes, John Stevens is fairly intelligent, he knows a little something about railroads, guess he's honest, but he is no diplomat. It's going to take a diplomat over in that country." When a well-meaning friend of mine broke in and said, "John Stevens not a diplomat? Why, I've known him for thirty-five years and maybe he don't talk often, but when he gets ready, he can talk more and say less than any living man." And the result was, I was picked for the job.

The Personnel of the Commission

That leads me to say that I hope I won't bore you today in this Russian business, but I have had no time to prepare anything. I would like to tell you something about our experiences, my associates and myself. As probably all of you did, being good American citizens, when we went into the war, we all offered our services. Mine were accepted by wire, and they asked me how long it would take me to get ready. I told them "twenty-four hours." I was playing golf in Bellaire, Florida. I came to New York at once and they sent for me to come to Washington and said that the Root Diplomatic Commission was going over and asked if I would take a membership in it. I said, "certainly." Then President Wilson wrote me a personal letter and asked me to come to see him. I found they proposed to form a commission of railroad experts, and that is the time when I was pronounced no diplomat. The Commission was chosen, consisting of George W. Gibbs, Henry Miller, W. L. Darling, John Greiner, who is consulting engineer at Baltimore, a bridge engineer—you all know him,—and myself. You will notice we had a civil engineer, Darling, an operating man, Miller, a mechanical man, Gibbs, a bridge man, Greiner, and I was supposed to have something of an idea about all four, so I was made chairman. The Canadian Government, at the request of our Government, held one of the big liners four days at Vancouver, and we sailed on that. We had an uneventful trip. And, by the way, our military attaché was Stanley Washburn—you have probably seen his name in the papers recently in connection with the visit of Queen Marie. He is a very fine gentleman. At Yokohama we were met by representatives of the Japanese Government. We first went to Tokio and paid our respects to the American Ambassador, Honorable Roland S. Morris, and I want to say that I have been around a great deal and met many able gentlemen, but I have never met a man that I admired more as an official than Roland S. Morris. He is a magnificent man with whom to work. The Japanese Government gave us a special train and we went across the Island to Tsuruga and took a Russian ship for Vladivostok. We were escorted over on the special train by 10 or 12 young Japanese engineers, and I am going to tell a little story to illustrate how difficult it is to get Anglo-Saxon vernacular adapted to the Oriental mind. We had to wait in Tsuruga three or four hours before the ship sailed and were given a fine luncheon. I was asked to make a few remarks. After doing so, I asked, "Are there any questions you boys want to ask?" They all spoke English. Some were educated in this country, but most of them in England. One fellow piped up and said, "You have been fairly successful, can't you give us some little advice or axioms, or principles, that you have followed?" I told them a few things, and among others I told them that I never crossed a bridge until I got to it. Dead silence. We walked down to the ship, when this little fellow came up and said, "Mr. Stevens, I didn't understand what you said about not crossing a bridge before you came to it. How *could* you cross a bridge before you got to it?" That cured me; I just tell the incident to illustrate the difficulties I met all the way through in dealing not only with the Japanese but with the Chinese and especially with the Russians. You had to be extremely careful in everything that you said. Their idioms are so different from ours that we are liable to mislead them.

Arrival at Vladivostok

We arrived at Vladivostok and were met there by a special train from Petrograd, sent by the Kerensky Government, with a lot of engineers, and there I got my first taste of the Bolsheviki. This was during Kerensky's time and I think it took four hours before they got through their speeches. The Russian's long suit is talk. I remember an address I heard one time in which the speaker said that if the Russians had been born dumb, they would have been the greatest people on earth. We finally got away from them and started across Siberia. That is a country of magnificent distances. It is 5,450 miles from Vladivostok to

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*Address before the Engineers Club, November 23, 1926.

Petrograd. We traveled mostly by daylight. I wanted to stop at many places, and now I want to say something about the Russian engineer. The engineer over there, I am speaking now of pre-revolutionary times, of the Czar's regime, practically any one who had any technical education, no matter what it was, forestry, agriculture, mining, of course, was an engineer, and was recognized as something a little better than the common educated people, in fact, was highly respected. We had, I suppose, on that train, about 50 or 60 Russian engineers representing almost every department of the science you could imagine. We got along first rate with them, and I commenced to size up the situation a little bit and decided that some diplomacy would be needed.

Russian Railroad Management Under the Old Regime

Finally we arrived at Petrograd and there were introduced by our Ambassador, Governor David Francis, to the Technical Board. This was strictly railroading, and the Technical Board consisted of 18 or 20 old professors, not one of them, I imagine, had ever,—well, had traveled, perhaps, on the railroad, but never had had any practical experience in management or construction. They sat in Petrograd in fine offices and laid down the laws for all the railroads in Russia. There were at that time about 33,000 miles of government owned railroad, and about 17,000 of privately owned, but all under government supervision. Among other things, once a month they met and distributed the cars for all the systems. You understand there is no such thing as a trans-Siberian railroad per se. There are seven different roads winding up in Petrograd, and starting from Vladivostok, of which probably three quarters are double track. In fact, all of them are double track for as far as Chita. There is a single line of track up the Amur River as well as the Chinese Eastern, and they unite at Chita, then they split again at the Urals, and one line goes north to Petrograd and the other south to Moscow. The professors would apportion all the cars of the systems. For instance, they would say, "For the next thirty days you can have so many cars, and like the laws of the Medes and Persians, the northern railroad might be short of cars and the fellow right next to him might have plenty, but he couldn't have one of those cars. That was the way they were managing the railroads, and I commenced to have some idea that I was in for it, so the five of us, Commissioners, attended the meetings of the Technical Board, and selected the member that seemed to specialize in bridging, for instance, mechanics, etc., and put him in charge of a specialist of our Commission. Then I was taken sick and went to the hospital where I stayed for three weeks—pretty nearly died, but I got out of it all right. As soon as I left the hospital, I found they had done nothing but talk and couldn't do anything but talk. I couldn't do much but talk, myself. I sent the Commission—I wasn't able to go myself—down to the Black Sea. They were given a special train, and went down to Southern Russia, the train being in charge of Mr. Miller. They were down there about ten days, and then I went down to military headquarters and tried to go out to the Galicia front where the fighting was going on.

At the Fighting Front

I didn't get within sixty or eighty miles of the front, but I had some interesting experiences, particularly with the commanding general, Brusiloff. I am telling you this to show you the difference between American and Russian practice in railroading. General Brusiloff was in command of the whole Russian army, and I asked him what he wanted. He said he didn't know, he was a fighting man, and he was; but he said that I should see his staff. I went to see them, and said, "What do you people want—let's get down to business." I didn't put it that way—was more diplomatic. They wanted 500 new locomotives. I told them I had already ordered 2,500 locomotives from the States, and when they came they would get their share. I asked them what else they wanted, and they wanted a big repair shop built here, another one built there. I said, "This first place where you want the shop, where you say you want to take care of a thousand locomotives, that is 300 miles inside the Austrian lines. How come?" "Well," they said, "in six weeks we'll be there." Long before that time came, they were throwing down their guns and running like the devil across the country. I said, "That's an impossibility. It would take three years to get the material and build those shops. You have to get rid of that idea; and in the next place, you have shops enough now, if you would man them properly to repair your locomotives." I tell you that to show you how impractical they are.

The Russian Engineer

The Russian engineer personally is a lovable fellow. I became well acquainted with a lot of them, but he is unpractical, I would call it. Now to understand why. Take the Russian railways, as an example: In the old days the railway was a close family communion. The children were sent to the preparatory schools, and there are no better in the world, and then to technical schools. A man could send his son there if he had some pull, but there were not enough schools. I say there was close communion, because they very seldom ever married outside of the railroad circle, so the children were born as railroad men. Well, they took a four years course, entered when they were fourteen and then went to a big university, graduated, and then were given high positions on the railroad. Perhaps some of them had never traveled on the railroad, but they were given high positions as superintendent, or some of them would be managers, and of course, all that nice uniform, with a great big insignia, and they went at it. How the railroads prospered, as they did in Russia, I can't understand for the life of me. Their rates were based on zones, fairly high, but, of course, their wages were very low. I think the average wage of a locomotive engineer or mechanician, as they are called there, would be about $42.00 a month in our money. In Southern Russia, in the Caucasus region, there is a road called, I think, the Trans-Caucasian, but no matter what the name is, it is a fine railroad, built somewhat on the American system. They used 90 pound rail, stone ballast, some heavy locomotives and, for them, some big cars; and they boasted of the only grain elevators in Russia, and it was a fact. This railroad began about 400 miles from Petrograd. It was about 1,000 miles long and followed the western shore of the Caspian Sea.

The general manager invited me to go down and see his railroad. He lived in Petrograd—his office was there, 400 miles from the railroad, and he said, if I could go, he would give me a special train. It used to be the custom when they wanted to honor anybody, to send out a special train and send along some ladies. He said that he would send one of his men with me to help do the honors. I had gotten accustomed by that time to the way to do things and I didn't propose to go that way and lose face, and I suggested that he go with me, and he said, "Really, now"—remember, he was the general manager—"Really, I don't know but what I ought to go. I haven't seen that property for over three years." You laugh, but that railroad in 1913 paid 62 per cent, and I sometimes wonder if that wasn't the reason. I may add that I didn't go.

An Open Line of Communication Was Needed

At that time the Turks held the Black Sea, the Germans had the Baltic Sea, which only left the White Sea, which was frozen up seven months in the year. The Russians had, two or three years before, begun to build a railroad through the wilderness west of the White Sea, to the Coast of Murman. The supposition is that the gulf stream whirls around the north end of the Scandinavian Peninsula, so that coast has been kept open all the year around. The problem put up to the Commission was this: to keep a dependable line of communication with the Russians open to the Allies. This was before they had fallen out of the game. The Black Sea was impossible, the Baltic was impossible, and Archangel was no good. The question was, could this new railroad, which was something like a thousand or more miles long, be made available, so I sent Mr. Darling to make a trip over it. He came back and I think he lost about forty pounds, pretty nearly starved to death, and the result of his report was, nothing doing on that railroad. That left us with that great long thin line, from Vladivostok clear to Petrograd, 5,450 miles, the only way we could keep in communication with the Russians, and that was the job handed over to us in the face of all this Russian indifference, to put it mildly. Mr. Greiner and Mr. Gibbs did all the work they could do, and they decided they wanted to go home, so I gave them a car, and they started across Siberia and went home. That left Mr. Darling, Mr. Miller and myself. I wanted to see more of the Siberian railroad, naturally, as that was the road we had to keep open. I think I had fourteen cars in a special train, and Mr. Darling, Mr. Miller and myself started and we had about, to put it moderately, 50 Russian Engineers with us. A lot connected with the head Government went along, ten or fifteen, and as we struck each division, we took some of the local officials over their line; and my particular business was sizing up these officials. We finally got through to Vladivostok. But I have gotten ahead of my story.

Advent of American Railroad Workers

Before we left there, Liveroski, the Russian Minister of Communication, or Secretary of Transportation we would call it if we had such an officer, made a request verbally first, then written, that we send over a lot of American railroad men to teach their men how to operate the railroads, and right here I might say one thing, to show what I was up against. One of the very foremost of their Board—I think he was President, said, "Oh yes, these ideas and changes suggested are all right. They would give better service, and be more economical, but what object is it to us if these railroads make a deficit, the National Treasury makes it good. If they have a surplus they turn it in. We have life positions, and there is no object for us to do anything." Some of them got life positions back up against a wall not long after.

I made arrangements with the Department of State, and picked up some 300 railroad men, including those the Baldwin Locomotive people sent over, and by that time Mr. Miller was ready to go home and Mr. Darling thought he had done all he could, which he had, and that left me all alone, with a small staff of Americans. I worked around on the Eastern end of the road awhile, and finally, got word there were 300 men coming on a transport. I received the word but a few days before they arrived, so I hustled down to Vladivostok to meet them, and the very day they arrived the Bolsheviki trouble started, for the Russian officials in the Provincial District, in the Maritime provinces, said, "If you put any of your men ashore, you do it at your own risk"—they couldn't guarantee their safety. They didn't know what was going to happen. That put me in a nice position. I had only four or five men with me, and a very limited amount of funds. Colonel

Emerson, now Superintendent of Motive Power of the Baltimore & Ohio, had charge of these men, and I said, "How much money do you have?" He said he didn't have any, that he started with 50,000 rubles but when he got to San Francisco he was ordered to send them back because "Stevens had plenty of money." Imagine me with over 300 men in a foreign land in war time without any money. I said to Captain Davis of the Transport, "What are your orders?" These men were still all on the ship. He said, "To get rid of this bunch just as quickly as possible, and get to Nagaski for a load of coal and then to Manila." I said, "I think we will go back to Nagasaki with you. We can't take our men ashore." "All right," he said, "we will take them back." On the road back to Nagaski I said, "Captain, I don't know what I am going to do with these men, but one thing I do know, I haven't time to communicate with Washington, and I won't send these men back home." I understood there were some Japanese resort hotels near Nagasaki, and we could probably get them ashore there. "Well," he said, "how long are you going to hold them?" I said, "I don't know." He said, "You know my orders." "Well," I said, "you've got to take my orders now." There was a case where I had to assume responsibility. It took us three weeks before we could get those men ashore, and we held the transport there all the time. Captain Davis was a jewel. I went to Yokohama and drew a lot of money from Washington, and then I was all right. That was practically the end of that period. One by one I got these men over, first on the Chinese Eastern and then out on the road—had them organized in units of fourteen for each division, a civil engineer, a mechanical man, a transportation man, an accountant, and so on right through, and their job was to sit there in the Russian Division Offices, and tell the Russians what to do, and it was a heart-breaking job. It took about six weeks or two months to get anything done. As manager of the railroads, I could have given my orders to a boy and the next day it would have been done, but not so with the Russians. I was in Vladivostok much of the time and part of these men were in Japan, and part on the Chinese Eastern Railway. That railway is a part of the Siberian railroads, a Chinese name, but it belongs to the Russian people.

Appointed Director General of All Russian Railways

I then received a cable from Petrograd saying that the Government wanted me to come there—the Provincial Government—very important, so I started, and went through 5,500 miles and took a couple of secretaries and interpreters with me, and found I had been appointed to what virtually meant Director General of all the Russian Railways, and that the Department of State had agreed to it, providing I was willing. I couldn't do anything else. I didn't want the thing, and I didn't know what I was up against, but I was in war service, so I said, "All right, anything goes with me." The Russian government had bought 6,000,000 bushels of wheat in Siberia, and that meant about 3,000 miles away, and late in the summer, and it had to be gotten over into Russia before the winter came. The main thing the Russian engineer was concerned about, was how big an office I wanted. That didn't concern me, and I told them to fix up any old place.

I took a special train and went to Moscow over this wonderful railroad the Czar had ordered built. You have all heard about it—"All straight, no curves." That isn't so, of course, but it is a beautiful railroad. The only drawback is weak bridges, about E-30 or E-35, and a few curves, very light curves—a fine railroad. I got to Moscow and knew about the situation. I had been there before, and I found 8,000 loaded cars there. Some of them had been there two years, loaded with supplies, food, ammunition, rifles, clothing, and medical supplies for the army at the front. For two years some of them had been lying there, and that was one of the factors why the Russian army broke up and left the front. I remained in Moscow nearly a week, got the blockade somewhat broken and the cars started toward the front. (They never got there, by the way.) Then I came east over the southern railway, picking up the divisional officers as I came along, to tell them what to do, and how soon they could expect this wheat to come, and finally I got east to Chillabinak, which is a city on the eastern edge of the Ural mountains. And here's another illustration of Russian official methods. In crossing the Ural mountains, the grade is about 1½ per cent, or something like that, with long stretches of a light mountain grade, so I picked up the division superintendents at different points and I said to one chap, "How many helper grades have you got, and where are they?" "Helper grades—helper grades?" "Where you have to use two locomotives." "Oh yes"—well, he didn't know, he would find out, so the next time we stopped he went into the telegraph office, I supposed to find out, and he came in a little while afterwards and told me there were three. I asked him where. He didn't know. Of course, I didn't immediately say, "You're a damn fool," but after a while I brought the conversation around to "How long have you been here?" "Seven years." And he didn't know how many pusher grades he had. That's the kind of material with whom I had to work.

The Bolshevik Trouble Begins

When we got back to Samara where we crossed the Volga River, we heard there was trouble in Petrograd, shooting and all. I didn't know what to do. I was alone—only had two or three Americans with me, but we pushed on into Moscow and there I found no trains running, no telegraph lines—there was nothing in the way of transportation. I couldn't even get a telephone message to Petrograd—didn't know what had happened there, and the Bolsheviks surrounded the city of Moscow. I went up one afternoon to see what would happen. Went to visit an art gallery and on the way back got shot at once or twice. Had a friend with me, a Russian Colonel, and I think they were shooting at him and not at me, but they killed a man right behind us.

I went back to my car. I was living in it down at the South Station, and if any of you have been in Moscow, you know where the South Station is. The next day the fun commenced, and we stayed there for five days of fighting. I suppose 6,000 or 8,000 people were mowed down on the streets, and I finally got tired of that, couldn't get any word from Petrograd, so I said to one of my interpreters, "You go to the Bolsheviki Commissaire and tell him I want to see him here." He said, "Why you have to go see him?" I said, "You do what I tell you or I'll throw you off the car." In about a half an hour Mr. Commissaire came around. "What does the Amerikanski want?" Well, he wanted a switching engine, to take his car down the Belt Line, and put it at the North Station, so it would go out on the night train, on a line that led north from Moscow, but struck the other main line 350 miles east of Petrograd. I don't think it was fifteen minutes before they had hold of us and moved us around, and I made him give me an order, which he gave very willingly, to put my car on the night train. I went to bed with three inch shells shooting around the city. Next morning, I woke up in Volga, 350 miles east of Petrograd. I tried to get into Petrograd that way but could not, but I managed to get a 'phone message to Governor Francis, our Ambassador, and he replied the whole thing was merely a flurry, and that Kerensky would come back stronger than ever. Finally, the soldiers moved away from the front and commenced to sweep across northern Russia into Siberia. You have all heard of the Trans-Siberian Express; so I got an order to put my car on the first train that came out (and it was the last one for three years), and put it on the rear end. I hoisted the American flag on it, and we started East in a couple of days, and it was some trip. I suppose there were a million, or a million and a half, of those soldiers sweeping across the country, all without food, living on what they could get from the peasants. They were loading the trains down—these little foreign box cars, about fifteen ton cars, and they were sending those trains out without orders or anything else, one right after the other. There were 480 soldiers burned to death in an accident on the Ural Mountains; but we got through on the east side of the Urals after a while, and we laid two days at Ekaterinberg. That is a beautiful city. It was here that the Czar and family were murdered. They wouldn't let us go any further. There is a great big yard down east of the station, about a mile and a half long, with a lot of tracks, and there were 38 soldier trains lying there and more coming in, and they were sending them out just as fast as they could see the smoke disappear without orders, but they wouldn't let us go. Finally, I went up to the station and worked a bluff on them. The agent said we could go, so they gave us orders, and we pulled down through the yards on a bright sunny morning, the tracks on either side lined with these soldiers in their 58 trains, with "God bless the American," and "God bless our flag," but we hadn't gotten ten miles before some of those soldiers went up and killed the station agent for letting us go. Finally, we got through, and I was very glad to see the frontier of Manchuria when we got there.

Maintaining the "Open Door"

I spoke about Ambassador Morris. After the Bolshevik outbreak—I am going ahead a little bit, I have been asked probably a dozen times, "What the devil were you doing over in Siberia after the Armistice? What business had you over there?" The real reason was to keep the John Hays "Open Door Policy" against our little brown brother and prevent him from grabbing the railroads. Mr. Morris and I conceived the idea that we ought to have an international board to look after those railroads—to keep the "Door Open." We didn't announce it publicly, but we knew that Japan was more concerned than any other nation, so the approval of the State Department was gotten, and we commenced negotiations with the Japanese Government. I went to Tokio and stayed there about four weeks. Every day Ambassador Morris and I had a conference with the Foreign Minister. He would advance the most wonderful propositions, which I turned down one after the other, and just when we thought we were going to succeed, they told us they wouldn't negotiate any longer in Tokio, but that they were going to take the matter up through their Ambassador in Washington. This was done to get rid of me, so I took the next train and went to Manchuria. After worrying along about a month or six weeks, the Ambassador and I working through cipher cable, we got a very weak agreement—very weak indeed. It all rested on my shoulders as to whether it was accepted or not. I was fighting for a little more power; but finally I got a message from the Secretary of State at Washington, in which he said that the reports he had of the deplorable conditions of transportation in Siberia were such that if I couldn't approve of the agreement as it stood—and my signature had to be on it—that he was afraid they would have to turn the railroads over to another nation. I knew that meant Japan, so as the agreement was the best I could get, I went ahead. Then Japan and the United States sent diplomatic notes to the Allied Nations and told them what they had done, to Italy, Britain, France, China, and the Russian government as represented by the Kolchak. That meant they could all join, which they did, and the gist of the agreement was that each nation was to furnish a technical representative to serve on a technical board, all presumably railroad men. Czecho-Slovakia came in afterward, which made the eighth nation, and I was named in the agreement to be the American member and also President, and my hands were free. The other members of the Executive Board had no authority. They could advise, but in matters of finance, operation, maintenance of the road, etc., I was absolutely supreme.

Now about the money. The first question I was asked was "How much money do you want?" Well, that was a pretty wild question with 50,000 miles of railroad to get into good working order. At that time it was expected that Kolchak was going to recapture the government. As a guess, I said, $20,000,000. I finally succeeded in getting some of it. There was placed to my personal account in the banks by the United States, $5,000,000; Japan, $4,000,000, and poor old China, $400,000. I transferred most of it to the American bank in Harbin. Holding the purse enabled me to keep control for three and a half years. Of course, I had the other nations back of me, and we supervised as much of the railroads as the Bolsheviki did not control.

After Kolchak was driven back, the Bolsheviks came on, and I kept pulling our men back. We had about 3,500 miles all told instead of the entire mileage of railroads. We functioned along for over three years and the last item, the last stipulation in the Inter-Allied agreement was, that when the last foreign soldier left Siberia, then our board would be dissolved automatically. We made an agreement with Japan, it was never publicly confirmed, that neither country would send over ten thousand soldiers. The United States sent 8,500, Japan 7,200. If the United States made any protest, it was made privately.

The soldiers all came out in the due course of time, with the exception of the Japanese, and they hung on until I thought they were not coming out at all; but they did leave Vladivostok, the last one the 25th of October, 1922, and on the first day of November, I dissolved the Board, and came home by the first of January, 1923.

The Future of Russia

It was a very interesting experience, one I do not regret in the least. I have been asked a thousand times, what is going to be the outcome in Russia? I don't know; nobody knows. To my mind it was a great disaster when Lenine died. He was a fanatic, but he was a thoroughbred Russian, and he had sense enough to see that he had made a mistake; in fact, he acknowledged it, and they were gradually swinging back to the right, getting back to sanity. He had to save his face with the Russians, and could not do it all at once, but he died, and they have been fighting all the time since. I think conditions are getting better. Of course, in the end Russia will get back to normalcy. She is a wonderful country, with marvelous resources, and Siberia is a white man's country. It is true, the winters are long, and it gets cold, at times 60° F. below zero, but there are no blizzards, and I have seen 104° F. in the shade in the summer. They plant wheat along in May, and about the first of August it is ripe and ready to harvest. They get sunlight from 3 o'clock in the morning until 11 at night. But I do think one thing, and I believe you will agree with me: A nation that has violated everything spiritual and every economic principle cannot last. First they tried to suppress all the churches, but the peasants wouldn't stand for that. The situation today as I get it, is that you can practice any religion you please without restriction. You can be Hebrew or Catholic, or anything you like, but the Bolsheviks claim there is no such thing as God; that's a myth. They are so teaching the young. They are really raising a nation of atheists, and I think that will ruin them in the end. You know what they have done economically. You can do that for a while, but sooner or later it will kick back, and it is kicking back on them now; but as I said before, it is a country of vast possibilities.

Russia can raise—or could five years ago—and put in the field 12,000,000 men, and there is no better soldier in the world than a Russian. He is not a coward. Russia quit because she had to. She can arm her men. She can build guns. I saw 6,000 of the 3-inch field guns lying dismantled, never been used, in one plant. She can make ammunition. She can feed them. She can clothe them, she can produce everything needed to carry on a modern war, except the one item of rubber.

Such a nation cannot be ignored. What they need is a driving, organizing force, for the Russian has very little initiative himself. He copies. I made the following remark several times, maybe it is crazy, but the Russian, high and low—to go back no further than Peter the Great—has never been allowed to think for himself—his thinking has always been done by the leaders in Petrograd, and I think, actually, that their brain is kind of atrophied, maybe not, but what they need is a strong hand over them; I mean economically. They want somebody to do their thinking, and not only need it, but they want it.

The Germans had Russia by the throat. As an example, in the old days in Petrograd, Moscow, any of the big cities, you would find all the equipment of a trolley car, the controller, practically everything was made outside the country, and so with almost everything else. Russia had the raw material in abundance, Germany would buy this raw material at low prices, take it over and sent it back in inferior products at a big price. Four hundred miles south of Moscow is the big Donetz coal basin, one of the big ones of the world. I suppose 60 miles square, that would be 3,600 square miles, with hundreds and hundreds of miles of railway through there, and some of those mines, in 1917, they told us, were 2,000 odd feet deep and equipped with the finest electrical machinery —mining machinery—that the world ever produced, from Germany. That coal is fine quality, and there is an immense quantity of it.

From Moscow, which is the business, banking, and commercial center of Russia, it is 400 miles south to those mines. They had a double track railroad laid with 90 pound rail, rock-ballasted, equipped with heavy American locomotives, and they had another single track road just as good. Four hundred miles from the center of Russia, from the biggest manufactories in Moscow, and 64% of all the coal they used for years came from Cardiff, Wales. That is only one example; therefore you see that they need leadership.

It would be a grand field for Americans if we could get in there. We ought to be there, but I was asked several times in Washington by the "Powers that be" what I thought about it, and I gave the same answer. Propaganda doesn't mean anything in the United States; it might make a little trouble in Paterson or in New York, but the farmers of the United States are the safety valve, and you can't do anything with them in the Bolsheviki line. I said that whenever the Soviet made an agreement that sounded good, when they assumed their obligations and agreed to pay their debts, then I would recognize them, but I would not until then. I was asked, "When are we going to get this money back you spent over there, $5,000,0000?" I said, "You will get it when you get the rest." "Well, is there any chance of getting it from the Soviet Government?" "Not a Chinaman's chance. Whenever you recognize them, and I think you will not recognize them until they agree to pay their debts, then you will get it back."

That five million dollars was spent as follows: Fifty to seventy per cent of all the traffic that we hauled on the railroads we got nothing for and consequently we were always "broke" financially. Suppose the Pennsylvania Rairoad could collect only 50% of its freight charges, how long would it last? That is exactly what we were up against. No money to pay wages. Sometimes the men got a little money to buy bread. Several times there were strikes, and I broke them with advances of money. The time when I was trying to get 60,000 Czech soldiers to Vladivostok over 3,000 miles through the Siberian winter, the railroad men had no money, had no bread—actual cases of starvation. The miners had no bread, could not mine coal for locomotives. I sent to the mines 25 heavy American locomotives and 450 big American cars, and then I bought $400,000 worth of rubles in Harbin—such rubles as they could use in Russia—could not use American gold. There were at least two carloads of these rubles and I am not exaggerating in the least when I say that.

I sent Colonel Johnson with twenty or thirty Czecho soldiers with a train to distribute this money. He did a splendid job, giving each of the miners some money; the railroad men some money, and also distributed nearly one hundred carloads of bread. Not bread as we understand it; when the Russian speaks of bread he means buckwheat, as a rule, for his bread is usually made of this grain.

Evacuation of Siberia

We had to bring out of Siberia sixty thousand or more Czecho-Slovaks, eighteen thousand Poles, some Rumanians, and soldiers of about four or five smaller nations. The English and French soldiers were already out of the country. To tell the truth the Czecho-Slovaks had to be brought out, for their Slavic blood and Bolshevistic inclinations commenced to permeate a little bit, and several of the regiments started to mutiny. I was told we had to get them out. They had not been home for three or four years. Had not even heard from home. They were drafted by the Austrians, forced to the front, nearly 100,000 of them. They hated Austria; they didn't want to fight for Austria and the first time they got a chance, 60,000 or 70,000 walked over and surrendered to Russia. Fine soldiers; even better than ours, with all due respect to the American soldier. It took about six months to move all those soldiers. The United States furnished ships for the Czecho-Slovaks and England furnished ships to get the men of the small nations back home, but that is a long story.

The Business Situation

THERE appears to be a general concensus of opinion among bankers and business men, who are in best position to judge, that the condition of business as it has existed for the past six months will continue at least through the first half of 1927.

In an address before the Chicago Association of Commerce, Mr. Melvin A. Traylor, President of the First National Bank of Chicago, and one of the best-posted bankers in the central west, stated that from his point of view, none of the basic elements that precede business depression or panics exist. He expressed confidence in a continuance of present conditions for at least several months.

"There are, however," he said, "one or two cautionary signals up, and these should be studied. One of these is the installment buying. These deferred payments are not in themselves dangerous, but the abuse of the methods applied may cause bad conditions.

"Another cautionary sign is the fact that so-called commercial loans have gone up $425,000,000 in the last year, while deposits have gone ahead only $300,000,000.

"Preceding every panic have been high prices, shortage of labor, high wages and high money rates. None of these elements exist at present."

Encouraging Outlook for 1927

Under this subhead in their monthly publication, the Guaranty Trust Company, of New York, write:

"The wide distribution, even more than the volume, of the public's purchasing power justifies the expectation that business will continue active and underlying conditions generally sound during the coming year. It is not to be expected that the rate of growth maintained during the last two years can be maintained indefinitely. Even if it be granted that growth is a normal feature of the country's business, and that the man-power now existing could, under better management, produce vastly more than it has even in the recent past, it remains true that such rapid expansion demands adjustment which must from time to time occasion temporary setbacks. It must be remembered, however, that a moderate decline from such levels as have existed this year would by no means mark the end of the present era of prosperity."

The National City Bank of New York State:

"The New Year opens with good prospects for the continuance of prosperity. The past year has been one of the most prosperous in the history of the country, but it closes without signs of either price or credit inflation. The general commodity price level, as computed by Government agencies, is about 6 per cent lower than a year ago; furthermore, of the nine general groups of the classification only one—fuel—shows an increase and this is largely attributable to the British coal strike, which has caused unusual exports of coal from this country in recent months. This general, but for the most part moderate, decline of prices, in the face of the largest movement of commodities ever known indicates that the heavy purchases have not been for stocks but for current consumption. All accounts agree that stocks generally are low and that trade is in healthy condition.

"The downward trend of prices has not been at the expense of the wage earning class, but of advantage to it, for the effect is to increase the purchasing power of a given wage. Financial conditions are favorable to a continuance of industrial activity."

Business Forecasts

A somewhat different attitude was shown in a recent circular of Goodbody & Co., many of whose forecasts in the past have been remarkably correct.

"It seems to us that, contrary to precedent, the bankers and general economists have been more optimistic in their expressions as to the general business outlook for 1927 than business men have been in speaking for their own industries. There has certainly been a very cautious tone to the published views of the latter class, which is in line with the attitude taken by business as a whole toward the entire period of prosperity through which we have been passing. It is just this cautious attitude that has made us feel sure that, barring unforeseen events, our next period of depression would be a slight one, not accompanied by the usual tremendous inventory losses, forced liquidation and red ink income accounts. We see on every hand the tendency to check production as soon as inventories show signs of accumulation, and there are very few instances in the business world where forward commitments for raw materials have been made on a liberal basis, or where plant capacity has been excessively expanded.

We have been helped this year to sell our manufactured goods by the extraordinary industrial situation which existed in England during the coal strike, and our business activity has undoubtedly had artificial stimulation from the spread of instalment selling. We can count on increased competition from European industry in world markets from now on, and this, with a lower price for cotton, may entirely wipe out our export balance. This will not be a bad thing in the long run, but it will require some industrial readjustments here. The instalment credit situation has probably nearly exhausted its possibilities for expanding demand, and at some time in the future the accumulated effect of this mortgaging of future income will hit us very hard. There is no reason to expect that this will happen in early 1927, however, and in the meantime the system helps us to continue our high rate of trade."

C. E. B.

Items of Interest

Compressive Strength of Column Web Plates and Wide Web Columns*

The investigation had as its major problem the verification of the design rule that wide web plates in compression should not exceed in width thirty times the thickness of the plate. It also included a study of the strength of laterally supported wide web columns and a comparison of the merits of single plate and double plate webs of equal thickness.

The tests show that while the common design rule is conservative, buckling strength is also dependent upon the mechanical properties of the material and that the buckling resistance of a plate may be computed for known material. Close agreement is shown between test results and computation by Bryan's formula.

The relative action of the single and double plate webs as exhibited by the few tests made does not indicate that either is inferior to the other when the material is identical. The stitch-riveting used was sufficient to make the plates act as a unit and indicated no decided detrimental effects from such riveting.

CONCLUSIONS

1. Web Plate Compression Strength.

1. A web plate in compression may fail through the development of a secondary failure by buckling, or by a primary failure.

2. The type of failure to be expected depends on the dimensions, support, and condition of the plate and the mechanical properties of the material.

3. The results of this investigation show that computed values from the theoretical formula developed by Bryan are in close agreement with best results, provided proper values are chosen for the Bryan formula.

4. The unsupported width must be so chosen as to insure freedom from lateral displacement at the plate boundaries and should, at least, be equal to the distance between connecting rivet lines, and preferably, in the case of thick plates to the full width of the plate.

5. The critical plate thickness—that is, the thickness at which either a secondary failure by buckling or a primary failure may take place—may be determined by substituting the value of the P. L. of the material for the stress at which buckling will occur in the Bryan formula.

6. For thin material in which the buckling stress by Bryan's formula lies below the P. L. of the material, failure by buckling will occur.

7. For thick material in which the buckling stress by Bryan's formula lies above the P. L. of the material, failure by buckling will not occur, a primary failure will take place.

8. On the basis of Bryan's formula it appears possible to make safe and more economical designs by computing the web plate thickness for a selected high-grade material, provided due care is taken to insure the plate material being free from excessive local curvatures. To provide for the latter, it may be necessary to increase the computed thickness arbitrarily so that for general design work an approximate rule like Fairbairn's may prove the more useful.

9. The Fairbairn rule limiting web thickness to one-thirtieth of the unsupported width is conservative for structural steels, provided the plate width is properly chosen. With care exercised in the selection of the plate material, the unsupported plate width may probably be extended to forty-five times the plate thickness, if the width is taken as the full width of the plate, or to thirty-five times the plate thickness if the width is taken as the distance between rivet lines, without danger of developing a secondary or buckling failure. For plate material five-eighths inch in thickness or over the unsupported plate width probably should be taken as the full plate width, especially if relatively thin flange angles are used.

To these conclusions may be added the following statements based on Bryan's theory relative to methods of stiffening wide web plates against buckling:

10. The strongest and most economical stiffening may be secured (a) by placing the stiffening element parallel to the direction of thrust, or (b) by decreasing web plate width about 6 per cent rather than by incorporating transverse stiffening frames.

11. If transverse frames are used they (a) should not be placed at distances equal to the width of the plate or multiples thereof (b) but should preferably be spaced one and four-tenths times the width of the plate, proper allowance being made for increased end stiffness of a plate due to filler plates, connections, etc.

2. Single Web Versus Double Web.

1. Provided the thickness of each plate is beyond the critical buckling thickness, the plates are equally straight and the material in the webs is alike, a double web column section should prove as efficient as a single web of equal thickness. Stitch riveting of such webs would, therefore, be unnecessary.

2. If there are inequalities in the alignment or in the material of the two plates of the double plate web, secondary effects will result which will make stitch riveting necessary in order to assure co-operative action of the two plates.

3. The stitch riveting used in these columns was sufficient to develop the strength of the web material, with no noticeable detrimental effects.

4. It is possible, as is indicated by the early development of stress lines about the rivets joining the webs, that riveting under heavy pressures and improper stagger of holes may be detrimental to the strength of double web sections.

3. Interpretation of Strain-Gauge Readings.

1. Where local bending is appreciable, caution must be used in estimating stresses from strain-gauge readings.

2. For reliable results, accurate measurements of the radius of curvature should accompany the strain-gauge readings.

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*Extract from the Bureau of Standards Technologic paper No. 327, price twenty cents (20c).

4. Strength of Laterally Supported Wide-Web Columns.

1. The strength of laterally supported wide-web columns depends upon the strength of their connections to and the relative stiffness of the supporting member.

2. The support furnished the columns of this investigation was sufficient to develop the strength expected as laterally supported columns before the strength of the connections to the stiffening element was exceeded.

Standard Specification Steam

Ordinary steam, as it comes from the average boiler, almost invariably contains moisture or dust. It is possible, with a well designed boiler, to operate it under such conditions that the steam from it will be practically free from these impurities. These conditions, however, are not practicable in ordinary commercial service. If it is desired to operate a boiler in such a way that the steam will be reasonably clean, there must be in the first place almost no concentration whatever, in the boiler water. In the second place, the boiling must be done in such a way that there will be very little disturbance of the surface of the water in the boiler drum. This means that the boiler must be operated at a fraction of its normal rating.

Operation under these conditions is extremely expensive. The maintaining of a very low concentration requires excessive blow-downs which means great waste of heat. Operation at extremely low ratings means that a far greater investment is required in boilers than is necessary to produce the required horse power provided the boilers were operated at ordinary commercial ratings, or are forced to higher ratings by the use of oil or pulverized coal.

Predicated on the above it can readily be seen that every boiler that is operated at a rating and concentration sufficiently high to justify its existence as a steam producer, there will be mechanical entrainment or pick-up of boiler water with the steam, caused by the violent passage of the bubbles of steam through the water and particularly through the surface film. Furthermore, when operating at high ratings, the withdrawal of steam from the boilers is so rapid that the moisture thus picked up or entrained is carried away through the steam nozzle and into the steam header or the superheater.

The moisture in the steam being, as it is, boiler water of the same concentration as the boiler water at the surface of the water in the boiler drum, carries away from the boilers large quantities of impurities in solution and suspension. The effect of these impurities on the various pieces of equipment in the Power Station are to directly reduce the amount of yearly return on the investment that the Power Plant produces.

Considering the various pieces of equipment in order,—First is the superheater. The superheater is added to the boiler for the purpose of increasing the temperature of the steam after the steam has been made. Introducing water into the superheater causes it to act as additional evaporating surface, a purpose for which the superheater was not designed, and at which it is not efficient. The first results, therefore, of introducing water with the steam into the superheater is a reduction in superheated temperature which of course reduces the thermal efficiency of the prime movers, requiring a greater amount of coal to produce the same quantity of electrical energy and therefore meaning a direct loss of many dollars per year.

The second result of introducing concentrated boiler water into the superheater is a reduction in the capacity of the superheater to perform its function. When the boiler water carrying impurities is evaporated in the superheater, the vehicle for carrying the impurities is thus disposed of and the impurities themselves are left as a fine hot gritty powder which in a great many cases adheres to the inside surfaces of the superheater elements causing an effectual coat of insulation and greatly retarding the flow of heat from the hot gasses to the steam. This also produces a direct loss in revenue.

If the steam which passes through the turbines at high speed contains dust, it acts as a sand-blast and erodes the blades and nozzles of the turbines, reducing their efficiency.

This reduction in efficiency may proceed gradually over a number of years until it becomes so marked that it is necessary to shut down the turbine for reblading. All of the steam used during this period, in excess of what would have been used had the water rate of the turbine remained normal, is pure waste—a reduction in the revenue produced by the station. Added to this, of course, is the cost of the reblading itself, and furthermore the cost of the shut-down.

A similar result is accomplished by the gradual plugging of the steam passages of the turbine by the impurities carried with the steam.

A very little reflection on the subject will convince anyone that it is a very expensive policy to allow material other than steam to leave the boiler by way of the steam nozzle.

As boilers and boiler operating conditions vary so widely and steam is used for so many purposes, there has never been a definite standard by which the quality of steam could be measured, or the quality of steam at one plant compared with that of another. The nearest approach to this has been the old expression "commercially dry steam," which is of practically no value whatever, as steam may be commercially dry and still carry over from the boilers many tons of impurities per year, at great cost to the plant owner.

This condition has now been changed. Standard Specifications for clean and dry steam are now available. They state with scientific exactness just what constitutes steam that is clean and dry—steam that can safely be used in a power plant without the slightest possibility of damage to the equipment. They provide a standard by which ALL steam can be compared. They provide the manufacturer of steam using equipment with a standard quality of steam, the use of which he can specify and be certain that his equipdement will function exactly in the manner that his designers anticipated. It provides the purchaser of steam with a standard by which he can judge the steam that he buys. They make it possible for the purchaser of the boilers to set a definite standard quality of steam for the boiler manufacturer's equipment to produce.

Such a standard for steam is something that has long been needed, and now that it is available for general use by all who employ steam in their business, it should be universally adopted and all steam used should be made to conform to the Standard Specifications. They are as follows:

> "Steam shall be free from all solids—both soluble and insoluble. Samples of condensed steam shall not show more than nine parts total solids per million, which is the tolerance to cover dissolved copper and iron from the test condenser, unavoidable dust contamination during the collection of the sample and its evaporation, and unavoidable errors in the laboratory determination of total solids.
>
> Steam shall be free from all moisture. Throttling calorimeter tests at any time shall not show a variation of more than 2-10ths of one per cent from 100 per cent dryness based on the determined normal of the calorimeter. The permitted variation of 2-10th of one per cent is the tolerance for unavoidable variations in radiation and thermodynamic changes."

S. G.

DEPARTMENT OF COMMERCE

Washington

Motor Fuels from Coal

Perfection of certain processes for the carbonization of coal may be expected to provide substitutes for oil and gas, if needed in the future, states A. C. Fieldner, superintendent of the Pittsburgh Experiment Station of the Bureau of Mines. He suggests that in the ideal process the full yield of primary oils will be extracted from the coal by carbonizing, then the coke will be converted by way of the water-gas reaction to carbon monoxide and hydrogen which, when heated under high pressures in steel autoclaves in the presence of suitable catalysts, may be converted into alcohols suitable for motor fuel. Doctor Fischer, of the Institute of Coal Research, Germany, has succeeded in making such a mixture of alcohols, which he termed "synthol," at 150 atmospheres pressure and 400°C. by use of a catalyst composed of iron oxide impregnated with alkali. The fuel gave satisfactory service in a motor-cycle engine. Methanol is now made in Germany by a similar process in copper-lined autoclaves, with zinc oxide as catalyst, at a manufacturing cost of 18 cents a gallon.

The Bergius process, recently developed in Germany for converting coal into oil, also offers great possibilities for the treatment of western bituminous and subbituminous coal. In this process, as used at Mannheim, pulverized coal, mixed with oil or tar to form a thick paste, is heated at 400°C. in a steel autoclave under a pressure of 150 to 200 atmospheres of hydrogen. Under these conditions the coal is converted into a black, tarry liquid which, on distillation up to 300°C., yields oils and tar to the extent of 30 to 60 per cent of the weight of the coal. The by-products are ammonia and gas.

This process, Mr. Fieldner considers, could provide in the future ample quantities of substitutes for the products now obtained from petroleum. Reserves of coal in the United States are ample for many years. The time when such a process can be profitably worked will be determined by price levels.

Low-temperature carbonization of coal at 450° to 700°C. as distinguished from the usual high-temperature carbonization at temperatures of 900° to 1,200°C. prevents the decomposition of the primary tar, obtains the maximum yield of liquid products and at the same time produces a solid smokeless fuel. At 450° to 500°C. the tar yield is two to three times that of the ordinary high-temperature process for making coke or gas.

The objectives for low temperature carbonization commercially are:

To obtain a larger yield of liquid fuels than can be obtained from high-temperature processes.

To provide a smokeless, easily ignitible solid fuel for domestic purposes.

To obtain a dry, easily pulverized, highly combustible, low-volatile material for pulverized-fuel furnaces, and at the same time to recover by-products.

To obtain a substitute for low-volatile semibituminous coal, for mixing with high-volatile swelling coals in order to make a suitable dense metallurgical coke.

Of these four objectives, the one common to all low-temperature processes is the increased yield of oil or tar. Liquid fuel, especially gasoline, seems essential for the continuation of our present highly developed system of automotive transportation.

German engineers are investigating the possibilities of combining low-temperature carbonization with powdered-fuel firing or of burning the semicoke on chain-grate stokers in large central power plants.

Considerable attention has also been given to combining low-temperature distillation with complete gasification of the resulting semicoke in by-product gas producers.

From a consideration of the many different processes that have been and are being tried experimentally it is evident that no one process has yet proved an unqualified technical success. The processes that depend on internal heating are simpler and require less capital expenditure per ton of coal carbonized, but they are limited to non-coking coals, weakly coking coals, or briquetted or pretreated coals; also the gas is of low calorific value and the light oils can not be recovered from the diluted gas except when the heating agent is superheated steam. Such processes, however, are promising for future development in combination with large central power plants or industries using large quantities of gas of low heating value when diminishing supplies of petroleum shall create a demand for the oils obtainable by low-temperature carbonization.

The processes that show relatively higher costs and use externally heated retorts will probably find their most advantageous field in making relatively high-priced smokeless domestic fuel from a cheap non-coking or poorly coking coal and producing also a gas of high thermal value.

The commercial success of low-temperature carbonization of coal in the near future must depend mainly on the sale at an adequate price of the solid product—smokeless fuel—rather than on the liquid and gaseous by-products.

In the Central and Western States, because of the fairly large margin between the cost and the selling price of the processed fuel it seems possible to work out a low-temperature process that can compete with high-temperature processes requiring more expensive raw material in supplying the smokeless fuel requirements of this region.

The results of Mr. Fieldner's investigations are contained in Bureau of Mines Technical Paper 396, "Low-Temperature Carbonization of Coal," which may be obtained from the Superintendent of Documents, Washington, D. C., at a price of 15 cents.

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Some Conditions in Japan and China*

By EMORY R. JOHNSON,

Dean of the Wharton School of Finance and Commerce, University of Pennsylvania

A HALF-HOUR discussion of Conditions in China must necessarily be limited to a brief consideration of some of the most important facts. The subject is large, and I shall attempt to consider only a few topics. As I shall speak in a personal way about some experiences, it may be well for me to start by telling how I came to visit the Orient.

For many years it has been my privilege to have in my graduate work at the University of Pennsylvania officials of the Japanese Railroads. They have been coming here year after year to study traffic and related problems at the University and first-hand with the railroad companies. Several Chinese railroad officials have also been students of mine and more of them have been students at the Wharton School, from which they graduated, the Wharton School being the undergraduate part of the work in Business Education. As it happens, the Director of Traffic of the Japanese Railways for many years was an intimate friend of mine. The Director-General of the Railway of China and the Traffic Director are graduates of the Wharton School, of the class of 1909, and they are but a few of the officials who from year to year were kind enough to ask me to visit their country. For several years, I was prevented from accepting the invitation, which was seconded by the Alumni of the University of Pennsylvania in Japan and China, but finally, this last summer, I felt I could go, and so I went.

Japan

It seems desirable to say just a word about Japan because there are many people who look with apprehension and suspicion upon the Japanese. I have none of that feeling myself, and I feel that possibly those who fear Japan in a political sense may have not seen the subject in all its aspects. Japan has a political problem for the future, but it does not involve the United States. Japan's political problem of the future is Russia.

The greatest heroic effort of Japan has been to hold Russia back from controlling Eastern Asia. The present situation of Russia, which makes her weak, is presumably a temporary one. Russia will again organize, and when she does, she will resume her pressure towards the East. Japan realizes that the time will again come when she will have to resist Russian pressure. That realization is the key to Japan's policy in Korea and in South Manchuria. It would be political suicide for Japan to become involved in any serious controversy with the United States. She would simply use up her store of energy in a conflict with a power infinitely stronger than she is, and put herself in the position of being at the mercy of her real rival which is Russia.

The apprehension that some people have in regard to Japan is probably due to the realization that Japan is forging ahead very rapidly in manufacturing and in industrial development generally. Japan is a perfectly marvelous country as regards its power of co-operation, and I emphasize this fact because, as I shall point out presently, Japan in this regard is exactly the opposite of the Chinese. The Japanese people are all one family. They feel that they are. It is not a mere phrase to be quoted. Their school books, I think, still carry what you and I and the educated Japanese also would recognize to be a legend,—the statement that the Japanese people are descended from the grandson of the Sun Goddess, and that the present imperial family of Japan are lineal direct descendants of the Sun Goddess. Although this is now regarded to be a legend, it explains in part the feeling which even the most cultured Japanese have, that they are all associated in one common political family for a common national purpose.

Their government is highly efficient, and is one of the most honest governments in the world. When the Japanese engage in manufacturing, shipbuilding, shipping and commerce, they have no difficulty whatever in organizing and conducting in an effective manner, large corporations. They have the ability to cooperate in a high degree. Japan is becoming a large manufacturer of textiles and builder of ships; and in consequence is taking away from us some of our present markets in the Orient. There is this consoling fact, however, that the more highly developed industrially a nation becomes, the greater does our trade with that nation become. Our greatest trade is with England; by far the largest trade with any of the continents is with Europe, and to the extent that Japan and the Orient become industrialized, not to that extent will we lose our markets, but in that measure will our trade increase. This fact may well be kept in mind by those who think of the present export of cotton cloth and other American goods to the Orient. Japan may become the Great Britain of the Orient within a generation, but that will not be to our commercial disadvantage.

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*Address before the Engineers Club, December 7, 1926.

Korea

Crossing from Japan to Korea, one finds himself in a land that is no longer "hermit kingdom." Ten hours from the time one lands at Fusan on the south coast of Korea, one is in the capital of that kingdom, Seoul, or Kaijo, as the Japanese call it, a city with broad streets, and automobiles in considerable number along with other kinds of vehicles. It is a city being modernized, perhaps too rapidly as far as aesthetic or cultural reasons are concerned, by the very efficient administration which the Japanese are giving Korea. If you visit as I did the mountains in the northeastern part of the country, and thus travel sixty or one hundred miles beyond the railroad, over the part of country occupied by the poorer people, you will realize the great possibility for the betterment of the eighteen or twenty million people there are in Korea, a possibility which is being made real in accomplishment by the Japanese administration.

China

My entry into China was by way of Manchuria, and at Mukden I met General Yang, the Chief of Staff of Marshall Chang Tso-lin, and was entertained by him, and by the civil governor of Manchuria, with both of whom I had conversations of some length, and from whom I got a little insight into the political problems of Manchuria. However, I am not going to dwell on Manchuria's problems because there are other things I want to discuss.

First of all a few words about the economic situation in China. China, outside of a few cities, is a man power country, and for the most part within its cities industry and transportation employ human energy rather than applied mechanical power. To comprehend what this signifies is difficult. Practically all of our wants are supplied by mechanical power. We live in a mechanical age, and are accomplishing large things because we have harnessed efficient power to serve us. The Chinese people, however, depend upon human power. In a city of 800,000 people like Tientsin, there are almost no horses. Some automobiles and trucks are used but you will see thousands of carts loaded with a half ton to a ton of freight, being hauled by four or five men. Five men easily have the draught power of a strong horse. The five men will cost the employer possibly a total of 75c to $1.00 gold a day. I doubt whether you could own and maintain, in China, a draught horse for 75c a day, gold. Human power, even when it is applied to hauling freight on the roads and streets, is probably the cheapest power in China at the present time.

I can best illustrate the effect that the use of human power had upon me by referring to what I saw in the port of Tsingtao, the port which the Germans built. They had been in possession of it only a few years, however, when it was taken over by the Japanese, and as the result of the Washington conference it was turned over by the Japanese to China. Among other things shown me on my visit there was the port. As we drove to the harbor our cars stopped a block or so short of the long pier and as our party walked down the street along the water front, I saw a long train of heavily laden carts being drawn toward the city from the pier by man power. The fact that I paused a moment to look caused the man I was with to say, "You may be interested in knowing what wages those men earn each day. They are probably earning from 20c to 40c Mexican." Forty cents Mexican would be 21c or at most 22c in gold. "If they work the entire day, from sunrise to sunset, in continuous employment, they may possibly earn $1.00 Mexican," which would be 53c. That indicates the cost of that kind of power.

As we walked down the pier, we passed a ship being bunkered by coal that was being carried aboard in baskets. A little farther down the long pier we came to two warehouses, and I saw a string of heavily laden carts that were being hauled down the pier from the city. "Can you tell me," I asked, "where these carts come from?" They explained that the carts were laden with goods and produce that had been brought into Tsingtao largely by rail, and partly by other means, purchased by the buyers there, and stored in "go-downs" or warehouses in the different parts of the city, and that these goods were now being brought to the pier to be put into the warehouses. Later they would be taken out of the warehouses and loaded on vessels for shipment abroad or to other parts of China. I asked, "Why not have railroad tracks between the warehouses and the ship? Why collect goods in the 'go-downs' in the city and haul them down here by hand and put them by hand in the warehouses and later take them by hand out of the warehouses and carry them across the intervening space on the pier and put them in ships? Why not minimize, as we attempt to do at home, the handling of freight by man power?" The answer was, "This is our way of doing it."

Getting into a tugboat, we went around the harbor and then got off near the end of the breakwater which was widened into a pier at the end, and I saw a string of railroad cars laden with coal being unloaded. The cars were open top gondola cars with solid bottoms and fixed sides. The coal was being shoveled over the top of the sides to heaps alongside of the tracks. I was told the coal was for bunkering ships. "Why not have a trestle," I inquired, "have cars with drop bottoms, run the cars up on to the trestle, drop the coal into pockets, and let the coal go by gravity into the ships?" The reply was, "That is not the way we do it here." We could see the entire harbor from where we stood, and there were no mechanical appliances to be seen in the port of Tsingtao. This illustration is significant because if mechanical power were to be used to reduce human labor, it would be at a large port where there are at least two million tons of coal brought for shipment by water beyond, not to mention the large quantity of products from the fertile province of Shantung.

From time to time as I watched the effects of a surplus population and of cheap human power upon economic life, I asked myself, "What, if anything, is ever to change this? Is China always to be static, or will it somehow or other become dynamic?" The question troubled me for some time, until the thought came to me that it was only the third generation back when American families were large, when there was very little check upon population in the United States. I have lived long enough to see the American family change in New England and in the South and in the West from a large to a small family, due to the pressure of a rising standard of living. The standard of living the American people have adopted is so high that large families are impossible. Perhaps our standard of living is too high! I am not at all certain but that it may be.

In China, there are no artificial checks upon population. Each generation brings into existence an equal number of people to live under the same conditions that the present generation lives under. Will something bring about an increase in the wants or desires of the Chinese people? Will they want more clothes, better houses, sanitary conditions of living and education for the masses? Will these things, which constitute a higher standard of living, come to be desired by the Chinese people? If so, then we shall see the working of the standard of living in the reduction of the size of the family.

One of the many men I talked with in China was the Mayor of Shanghai, Dr. Ting, who was educated in England, and has traveled in this country. He is a mining engineer, who gave up his mining engineering work and took his present position at a reduction of $8,000 per annum in salary in order that he might undertake the task of organizing the government of the Chinese port of Shanghai. He said, "You may not be able to see the social forces that are operating in China." He referred to the fact that the educational system of China had been modernized more than twenty years ago, that modern education had really been adopted in the cities, and that it would gradually make its way through the villages and the rural parts of the country. He also called attention to the press in China; he spoke of the labor agitation, resulting from organization and propaganda.

The Present Political Situation in China

That there is a ferment in China is evident. The present political situation is one indication of that ferment; and, though not so easily seen, there is an economic ferment that will produce in time—not immediately for things don't change over night in China—different social standards and bring about the substitution of mechanical power for human power. Population will be checked. Man power will cost more, and machines will be more largely used. With that substitution will come a different economic order in that great country.

Everyone is interested in the present political situation in China. It is complex, and yet, in a way, it is fairly simple. The Central government has become weak, but we may well remember that China has never had a strong central government. Although one of the oldest countries in the world, with a recorded history that goes back five thousand years and more, it has gotten along for the five milleniums without a strong government. The Manchu power was swept aside in 1911 by the Revolution, and in 1912 a republic was set up. Republican institutions have not succeeded. The Parliament met twice but accomplished very little. The power, such as was created by the constitution, became resident in Yuan Shih-kai, the first president of China. He was the government of China, but he lived only a few years and the power of the Peking government passed to the Provinces. It happened in this way. The President, under the constitution, appointed the Governors of the several Provinces, twenty-one in number, which territorially correspond roughly to the States in the United States. The conditions of disorder which followed the Revolution made it necessary to have military forces and military governors in the Provinces. In a short time, the civil governors became subordinated to the military governors, and from among the military governors there have emerged quite naturally, certain men stronger than the others. The government of China today is in the hands of five or six men.

In the north are the three large Provinces of Manchuria. Marshal Chang So Lin is the dictator of that part of China. To the Northwest is the territory dominated by the so-called Christian General, Feng. The section including Peking, on the North, and until a few months ago, Hankow on the Yang-Tse River to the South, was the bailiwick, when I was in China, of Marshal Wu Pei-fu. During the nine days of my stay in Peking, which was in the latter part of July, 1926, the siege of Nankow pass was going on. The pass is only twenty-five miles in an air line, from Peking, but we hardly realized that a war was going on. Marshal Wu Pei-fu later captured Nankow pass, and drove General Fent back. The Marshal's star was in the ascendant. In the short time that has since elapsed, he has been eliminated from the picture, having failed to withstand the pressure of the southern forces that have come north, taken Hankow and Wuchang and have pressed down the Yang-Tse River to the important city of Kiukiang on the Yang-Tse River, which they have also captured.

In the Lower Yang-Tse Valley Marshal Sun rules. Marshal Sun had been told of my prospective visit to Nanking and Shanghai, and that part of China, and in consequence I was shown every possible courtesy by the political authorities not because of his interest in me or in what I had done, but because the man who was entertaining me was one of his right hand men, the Director of the Railways of the Shanghai-Nanking and the Shanghai Hangchow Railway. Mr. Yin was authorized to do everything possible for me.

I had two interviews with Marshal Sun who is one of the most interesting and one of the ablest men I have met, a man with a clear, direct mind, a man who is desirous of doing what he can to build up the five Provinces that he then controlled. He is the military governor of Kiangsu, in which Nanking and Shanghai are located, and is, or then was, the commander-in-chief of the military forces of four adjacent Provinces. The total population of the five provinces is about eighty million people, so when I talked with Marshal Sun I conversed with the dictator of eighty million people. At the dinner the Marshal gave, I was anxious to bring up the subject of government. When one is the guest of a dictator, it is rather embarrassing to discuss the question of government, so I had some difficulty in bringing the subject forward, but when I did the Marshal took up the discussion with surprising interest, sketching with a pencil as he talked. He said, "As you know, local government in China has never given us any trouble." He mentioned the well-known fact that the social unit in China is the family, that all three generations live together, if possible, in the same compound, that there is a head to each family which is a self-contained social and governing unit. The relations of one family unit to the next family unit are determined by age-long traditions; and local government takes care of itself. It is this fact that has given stability to China down through the milleniums.

Marshal Sun's next remark was, "The simplest problem of government in China will be the one first solved." That sounded sensible, and he continued, "You know that the political subdivision above our villages and purely local communities is the district of the Province." In his own Province of Kiangsu, there are 46 districts, which correspond roughly in size and number to the counties in Pennsylvania. The first problem of government worked out, the Marshal said, will be the organization of the administration of these districts, and when they function effectively, the development of government in the Provinces will follow. The evolution of the Provincial government will go on at the same time that the government in the Districts is being developed, but being a longer process it will end later. It is the Marshal's opinion that when the several Provinces of China have worked out their political problems they will establish, presumably by delegation of powers, a real central government.

That seemed to be a logical and convincing theory of political evolution and it interested me for two reasons. First, because it is the old Anglo-Saxon way by which governments have developed. Such was the process in this country. First there were the scattered settlements, in time the settlements got together and the several colonial governments were created. In the course of time these colonies became States. The States established, first a weak central government, and then after a short and unfortunate experience, a strong central government. The government thus established has, in the century and a third that has elapsed, evolved into a strong and very effective national government. Such has been the line of political evolution here. Marshal Sun says it will be the course of political development in China. The theory interested me also because that kind of development is slow. It takes time. China, under this process of political evolution will not have a strong central government in your day or mine; it may be a hundred years, possibly, before the evolution is completed.

The last night I was on Chinese soil I was entertained by the Alumni of the University of Pennsylvania. The toastmaster was a man by the name of Quo. He graduated from the University about 1910, and is a man of consequence in China, having been Vice Minister of Finance in 1920. He is now President of the College of Commerce at Wuchang, recently captured by the Southern forces. I brought up the subject of government, and without his knowing that I had talked to anybody else on the subject, he gave his theory, which was practically the theory that Marshal Sun had expounded two or three weeks previously.

The present political situation in China is uncertain. The Southern part of China is controlled by the Canton forces, now led by General Chang Kai-Sheck. General Chang Kai-Sheck in the South, Marshal Sun in the lower Yang-Tse Valley, Marshal Chang So Lin in Manchuria, General Feng in the northwest are the governments of their parts of China. The central part of China, including Peking, is now in dispute. Chang So Lin and Sun, with the support of the military governor of Shantung, have now united to stem the advance of the southern forces and if possible to drive them back.

Of course, one never knows what may happen over night in China, particularly under present conditions of contention among the military governors. I wouldn't dare predict what the outcome of the southern advance will be. My thought has been that the advance would wear itself before Shanghai and Peking are reached, and so it probably will, unless the radical sentiment in China, under the stimulus of Russian propaganda, is strong enough to enable the southern forces constantly to recruit their strength and gain new forces as they advance to the occupation of new territory. I have no way of measuring the extent to which this anti-foreign and radical feeling can be capitalized for the overthrow of the northern war lords by the Cantonese forces led by Chang Kai-Shek. My guess is that Chang Kai-Shek within a year will be back in Canton and that China will be ruled by a number of war lords for several years to come. This is a mere guess, however.

Imhoff Tanks—Reasons for Differences in Behavior[*]

By HARRISON P. EDDY,[**]

M. Am. Soc. C. E.

THE modern sewage disposal problem had its beginning about the middle of the past century, following the introduction of public water supplies. The early attempts to solve the problem were crude and empirical. Modern solutions, however, are based in large measure on scientific principles.

Fifty years ago the science of bacteriology was in its infancy. Its applicability to matters of stream pollution and sewage disposal had not then been grasped.. It was not long, however, before it was shown that oxidation of the organic content of sewage was effected through the agency of living organisms. Particularly noteworthy are the researches of the Lawrence Experiment Station of the Massachusetts State Board of Health, begun in 1887 and still continuing. The studies made by investigators at this Experiment Station, and by others, established the basic principles underlying the oxidation processes of sewage treatment prior to the beginning of the present century.

The treatment of sewage in an effort to render it inoffensive was undertaken long before the principles involved were understood. Probably the earliest method was that of broad irrigation, or the application of the sewage to relatively level but practically unprepared areas of farm land where it could be absorbed and purified by the soil. Later, when some of the fundamental factors became known, intermittent filtration was developed. In this method, which is a modification of broad irrigation, the crude or settled sewage is applied to the surface of carefully prepared areas of sand or other fine material. Another early method was clarification by means of chemicals. Later, filter beds of coarse material were developed, with special devices for intermittent application of the sewage and with provision for ample aeration.

Experience soon showed that with practically all types of devices for oxidation of the organic impurities, preliminary removal of suspended solids by settling the sewage in tanks is desirable. Such tank treatment, however, produces a bulky, ill-smelling and objectionable residue or sludge. Study and research, in this country and abroad, demonstrated that such sludge, if allowed to remain in the tanks, undergoes bacterial decomposition or digestion which results in the liquefaction and gasification of a large proportion of the solids and the production of a residual sludge of relatively inoffensive characteristics.

The combination of the sedimentation of solids and their digestion has been utilized in the septic tank, the Travis tank and the Imhoff tank.

The septic tank is a sedimentation tank designed and operated so as to foster the decomposition of the settled solids in the absence of oxygen. It was originally believed that this process is capable of nearly complete conversion of the deposited solids with liquids and gases, experience, however, has shown that this view is not justified and that the proportion of solids thus converted is much less than at first thought. Furthermore, such tanks, unless covered frequently give off offensive odors, produce black and foul effluents, and present numerous operating difficulties.

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Because of these conditions the favor in which the septic tank was once held has turned largely to the two-story tank. The best type of two-story tank is that named after Dr. Karl Imhoff, who developed it for use in Germany in the Emscher District of which he is Chief Engineer. The Travis tank has never been adopted in the United States.

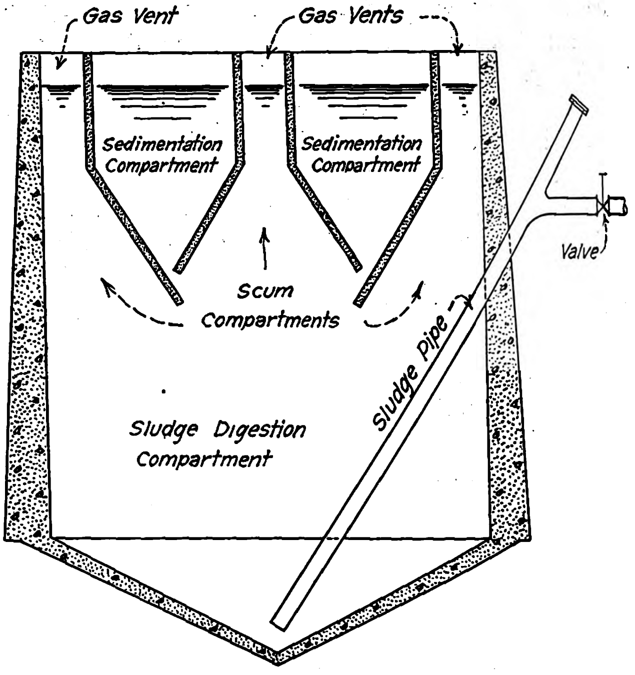
The Imhoff tank consists essentially of an upper compartment in which sedimentation of solids occurs and a lower chamber in which their digestion takes place. The two compartments are separated from each other by sloping partition walls on which the solids slide to a longitudinal opening or slot through which they pass into the lower compartment. The sloping partitions are arranged so as to trap the slot and prevent rising gases or solids from re-entering the sedimentation compartment. From the upper portion of the digestion compartment, gas vents or scum compartments extend to the top of the tank.

There are two primary functions of Imhoff tanks: one, the deposition, in the sedimentation compartment, of suspended solids contained in the sewage; the other, their conversion into inoffensive, relatively stable matter, in the digestion compartment.

The principal difficulties experienced in the operation of Imhoff tanks have been connected directly with the action going on in the digestion compartment. Solids that pass through the slots may be divided into two classes, namely, those of greater specific gravity than the sewage, which settle to the bottom, and those of less specific gravity, which float in the scum compartment. The proportion of solids of the latter class is small. Such solids comprise substances which have been entrained in the mass of heavier solids and thus are caused to settle in the sedimentation compartment.

The solids which are removed from the sewage by sedimentation, with the exception of sand and mineral detritus from storm water and certain industrial wastes, are essentially organic, although such organic matter contains mineral ingredients. These organic substances are in a state of decomposition owing to the action of bacteria and other living organisms, or their enzymes, present in the sewage and propagated in the digestion chamber of the tank.

The organisms decompose the organic matter into gases, soluble substances and insoluble material. Some kinds of organic matter are more easily and more quickly decomposed than others. Of the products of decomposition, the gases escape, by solution in the liquid, or by passage through the gas vents into the atmosphere. The soluble substances are dissolved in the liquid in the digestion compartment from which they escape, either by diffusion through the slots, or by withdrawal with the sludge. The relatively stable solids remain as sludge and scum until withdrawn. From 30 to 50 per cent of the weight of solids removed from the sewage escape in solution or as gas, leaving 70 to 50 per cent as solids in the sludge and scum.


Gas Vent
Gas Vents
Sedimentation Compartment
Sedimentation Compartment
Valve
Scum Compartments
Sludge pipe
Sludge Digestion Compartment

IMHOFF TANK—TYPICAL SECTION

The digestion of the organic matter results in the production of a practically inoffensive sludge, which is generally black, somewhat flocculent, and well filled with entrained gas as drawn from the tank. The digested sludge drains and dries readily when spread on porous beds of sand or similar material. Digestion sufficient to produce these characteristics may be considered complete for practical purposes, although the residual sludge usually contains about 50 per cent of organic matter.

The complete conversion of the fresh sewage solids into well digested sludge requires time, the length of which is greatly influenced by temperature. At a temperature just above freezing, scarcely any digestion takes place, while at 70° Fahr., digestion proceeds rapidly.

In northern climates there is great variation from season to season in the temperature of air and sewage and, most important of all, of the solids and liquids in the digestion compartment. In summer, when the temperature in the sludge compartment may be from 65° to 70° Fahr., digestion is rapid, but in winter it is greatly retarded. The digestion process follows a seasonal cycle. In summer the sludge may be in excellent condition, deteriorating during the fall, becoming quite offensive in winter, and gradually improving in the spring. Obviously, therefore the digestion compartment must be of sufficient size to accommodate the solids deposited in the late fall, winter and early spring, so that it will not be necessary to withdraw partly digested and offensive sludge.

The solids as first deposited form a thin, voluminous sludge. As decomposition progresses, they are disintegrated and, being finer, tend to become compact. This tendency is aided by the weight of solids subsequently deposited. As a result of these conditions, the mass varies in consistency from a thin, watery material at the top to a comparatively thick sludge at the bottom.

Gases generated during the decomposition of the solids gradually increase in volume until they permeate and buoy up quantities of sludge which pass into the overlying liquid. If there is opportunity for the entrained gases to escape from the rising sludge the solids heavier than water will return to the sludge mass. In practice, however, the gases escape with some difficulty, and masses of sludge are carried into and remain in the scum compartments, thus forming a thick, bulky scum consisting of solids heavier than water as well as of those which are of less specific gravity. If the sludge or the scum becomes extremely compact, the opportunity for the proper functioning of the organisms appears to be reduced and the digestion process is greatly retarded and may be quite incomplete.

At some plants, the gas rising in the vents has produced a light, voluminous foam, due to tenacious films enclosing the gas bubbles. At times this foam has accumulated in considerable masses, filling the gas vents, overflowing their walls, and spreading over walks and sedimentation compartments.

Excessive accumulation of scum in the gas vents, has been another serious obstacle to successful operation. In some plants the scum has risen above the tops of the gas vents and, in others, it has extended downward practically to the elevation of the slots. Under the latter condition, solids have been carried upward through the slots into the sedimentation compartment, from which they escaped with the settled sewage, greatly decreasing the efficiency of sedimentation.

Under some conditions scum formation is so great that the proportion of solids remaining in the bottom of the tank is so small that it is practically impossible to remove any solids in the form of sludge without first driving down the scum by breaking it with paddles, or streams of water, to liberate the gas. If scum is thus broken up and the solids are allowed to settle, they rise again in a comparatively short time, often within 24 hours.

In certain plants difficulty has been experienced in obtaining an inoffensive sludge that will dry rapidly on sludge-drying beds. Offensive odors have escaped from the Imhoff tanks at some plants, although generally speaking these tanks are practically free from odor.

While temperature has a most important influence upon the rate of biological action, there are a number of other conditions which affect the process favorably, or adversely, as the case may be.

Ample food supply and moisture are always present in the sludge compartment of an Imhoff tank. Although evidence is lacking, there is a possibility that different sewages produce sludges of such diverse composition that corresponding variations are produced in the predominant organisms, with resultant variation in the kind and intensity of biological action.

Light, oxygen, and inorganic poisons are of relatively small importance in the practical application of the process of digestion. The circulation of liquid between the digestion and the sedimentation chambers and the periodic withdrawal of sludge cause the more or less effective removal of products of decomposition. It is probable, therefore, that the "self-poisoning" of the essential organisms in the sludge is not an important factor.

The reaction of the sludge in the digestion chamber has a marked effect on the digestion process. In certain instances, notably at the Pennypack Creek plant at Philadelphia, Pa., the correction of acidity by the use of lime resulted in marked improvement in the behavior of Imhoff tanks. Valuable research has been and is being carried out in this connection at the New Jersey Agricultural Experiments Stations, at Harvard University, and elsewhere. These researches have indicated the practicability of controlling the digestion process by the addition of lime, or calcium carbonate, to decomposing sludge. The addition of these substances makes it possible to produce (in the mass of sludge) the hydrogen-ion concentration most favorable for satisfactory digestion.

Another important factor is the retention at all times of ample quantities of well digested sludge in the digestion compartment. This requirement results from the necessity of providing material to "seed" freshly deposited solids with the proper kind of organisms.

The substitution of gas for water in the voids of scum may render it less easily broken down by organic activity than is the case with wet sludge. Furthermore, there is much less opportunity for washing out the final products of biological activity and correspondingly greater opportunity for self-poisoning of the organisms of decomposition. These conditions are particularly favored by allowing the scum to remain undisturbed for long periods.

In general, two kinds of decomposition develop: First, the production of carbon dioxide by the splitting of non-nitrogenous organic matters, or fermentation; and, second, the production of methane by the splitting of nitrogenous organic matters, or putrefaction. Both kinds of decomposition may be included in the digestion process.

The initial decomposition of solids in a digestion compartment, when first put into operation, results in the production of a large proportion of carbon dioxide, due to the fact that fermentation starts at a rapid rate. Under favorable conditions, however, the character of decomposition quickly changes and methane becomes the pedominating gas produced, roughly, 85% of the total volume. Hydrogen-ion control affords a means of hastening the second type of decomposition.

Aside from the purely biological and chemical factors, details of tank design are important. Among such details are length, depth and capacity of different compartments; area and arrangement of gas vents; and other significant features. Exact scientific data upon which to base design are as yet relatively meager. As experience and research adds to the store of knowledge, more and more intelligent designs can be developed, although the exercise of sound judgment will always be required.

Imhoff tanks must be carefully and intelligently operated in order that their functions may best be developed. Operators should keep adequate records and should make sufficient analytical determinations to guide them in the operation of the plants in their charge. Satisfactory results in the operation of Imhoff tanks are as dependent upon skilled operation as on good design.

From a study of the evidence afforded by certain installations of Imhoff tanks, conclusions may be drawn with respect to some of the important factors in their design and operation. It seems evident that mineral and heavy relatively stable organic matter, such as are present at times in sewage from combined sewerage systems, tend to prevent the formation of excessive scum and foam, whereas the coarse and uncomminuted solids from separate systems have the reverse effect. In the case of sewage from municipalities having very hard water supplies, the formation of insoluble soaps probably bring about a substantial increase in the colloidal solids of the sewage and favor the formation of foam and scum. It is quite clear that, due to variation in the quantity of suspended solids in different sewages, the design of the digestion compartment of an Imhoff tank should be based upon the quantity of solids to be deposited in it rather than on an arbitrary assumption of a definite number of cubic feet per capita.

All the evidence shows that temperature is a factor of fundamental importance in the digestion process and, that the required capacity of digestion compartments is governed largely by the available temperature and, by the duration of the periods of low temperature. It is advantageous to draw sludge as early in the spring and as late in the fall as possible without removing offensive smelling sludge. It is also well to withdraw as much of the accumulated sludge as practicable, subject to the retention in the tank of sufficient volumes of favorably digesting sludge for "seeding" freshly deposited solids.

Preparatory treatment by fine screening appears to be beneficial, although not a necessity, because it affords a factor of safety due to the reduction of the quality of coarser materials which tend to form scum. The advisability of installing fine screens is largely a matter of relative costs.

In tank design and operation every effort should be made to secure uniform distribution of the deposited solids through the digestion compartment. Frequent reversals of flow is necessary for the successful operation of multiple compartment digestion chambers.

Deep tanks appear to have a decided advantage in preventing excessive scum formation and in producing a sludge of comparatively high density. Shallow tanks require substantially more digestion compartments capacity than do deep tanks for the same contribution of solids.

The evidence does not justify final conclusion regarding the comparative merits of small and large gas vents or, the best arrangement for such vents.

Briefly stated, essentially unfavorable conditions are shallowness of tanks, inadequate digestion compartments, non-uniform distribution of sludge throughout digestion compartments, large number of digestion compartments, absence of heavy solids from street washings, relatively large proportions of insoluble soaps, low temperatures, and the establishment of unfavorable reaction in the sludge and scum.

Experience with the Imhoff tank, as well as with other developments of sewage disposal practice, illustrates the dependence of engineering upon science and research. In the absence of adequate scientific data, the early designs of Imhoff tanks were based upon more or less arbitrary assumptions. Experience has added much to knowledge of their behavior, but additional information is needed on both the biological and physical phases of the process of digestion. The sanitary engineer welcomes the assistance of the scientist whose research into fundamentals makes Nature the servant of man, not his master.

Experiments in Welding Steel

A new welding process which, it is announced, promises to give the construction industry more rapid fabrication at a lower cost and a relief from the noise of riveting, has been tested with satisfactory results at the Bureau of Standards of the Department of Commerce. In announcing the test, Bureau scientists referred to it as "another step in making possible noiseless steel construction by welding instead of riveting."

Conversion of Coal Into Liquid Fuels

Addresses by
F. BERGIUS, FR. FISCHER and GEO. PATART*
Abstracted by
HORACE C. PORTER

At the National Coal Conference held under the auspices of the Carnegie Institute of Technology, at Pittsburgh, November 15-18, 1926, the outstanding feature, and the one arousing the most lively general interest, was the discussion on the subject of Conversion of Coal into Oils or Liquid Fuel. This was presented in three principal addresses, namely, those of Friederich Bergius, (Germany), Franz Fischer, (Germany), and Georges Patart, (France).

These addresses presented the latest progress along the following lines:

(1) Bergius—The direct liquefaction of coal itself, in one step, by chemical action of hydrogen at high pressure and elevated temperatures;

(2) Fischer—The action of hydrogen, in the presence of catalysts, upon carbon monoxide, as in water gas obtained from coal, using elevated temperatures and either a certain degree of high pressure, (for obtaining "Synthol," a mixture of alcohols and other compounds), or merely atmospheric pressure (for obtaining "Gasol," a mixture mainly of hydrocarbons);

(3) Patart—Carefully controlled chemical action of hydrogen, at certain ranges of high pressure and temperature, in the presence of certain catalysts, upon carbon monoxide, so as to produce, in one step, nearly pure methyl alcohol, not requiring secondary refining; or, under different conditions, mixtures of higher alcohols.

	Bergius	Fischer	Patart
Raw Materials	Coal (mixed with oil to a paste), plus hydrogen	Coal, through medium of water gas	Coal, through medium of water gas
Approx. temperature used (deg. cent.)	400 - 500	400 (a) 200 - 300 (b)	350 - 400 (c) 400 - 450 (d)
Approx. pressures used (atmospheres)	150 - 200	120 (a) 1 (b)	130+ (e)
Yield, total liquid fuel:			
Percent, by wgt., on coal	40 - 70	14 - 16 (b)	
Gals, per ton (2000 lbs.)	107 - 185	40 - 45 (b)	150 - 160 (c) 100 - 110 (d)
Yield, motor fuel, gals., (average)	45	......	(g)
Net Yield, Average, (allowing for coal used in process):			
Total liquid fuel, gals	104	......	......
Motor fuel, gals	35	......	......
Additional products, or By-products	Rich gas about equal to, and ammonia about double, the yield from ordinary gas retorts. (f)	Residue of unaltered water-gas, —amount not stated	"Purge gas" or enriched residue from orginal water-gas — amount not stated.

(a) For Fischer's "synthol," a mixture of alcohols and other compounds.
(b) For Fischer's "gasol," a mixture of hydrocarbons, obtained by working at ordinary pressure.
(c) In making methyl alcohol only.
(d) In making higher alcohol mixtures.
(e) Specific statement not made by Patart on the degree of pressure used; this value given by Fischer.
(f) The rich gas may be recovered as a by-product or may be converted by a special catalytic process into a hydrogen-rich gas to be recirculated; in the former case additional coal or coke must be used to make hydrogen, and the net yields of oil per ton are considerably reduced from those given in this table.
(g) The product first obtained consists mainly of alcohols, and may be converted by a second step (special catalytic treatment) into a mixture, partly hydrocarbons, well suited to use as motor fuel.

In tabular form, for the sake of a quick survey of the essential practical results obtained in these three processes, the above data is of interest.

By processes of carbonization, thus far developed, either at high or low temperatures, the maximum yield of liquid fuels from bituminous coal has been 15 to 35 gallons per ton, and of oils suitable for motor fuel about 5 gals. Hence these newer processes of chemical treatment, whereby 50 to 100 gallons of total oils, and 15 to 40 gallons of motor fuel, may be obtained per ton of coal, offer, especially to the European countries where petroleum supplies are limited, an important prospect of supplementing the natural oil resource.

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*To appear in Proceedings of the International Conference on Bituminous Coal, Carnegie Institute of Technology, Pittsburgh, Pa., November 15-18, 1926,—in press.

Although the operating and plant costs are not as yet known with certainty, it appears probable that motor fuel cannot by these processes now be made in America at costs to enable it to compete with gasoline. But on the assumption of an increasing shortage of petroleum with rising price of gasoline in this country, and a probable reduction in costs of operating the new processes as they are further improved, it may be predicted that these processes at no very distant date may become economically feasible in this country.

The Bergius Process

Bergius believes it is more rational to add hydrogen directly to the existing carbon-hydrogen bonding in coal, thereby forming liquid compounds, than it is to break down this bond first, as in Fischer's and similar processes, by forming carbon monoxide from the coal and reducing this by hydrogen in a second step.

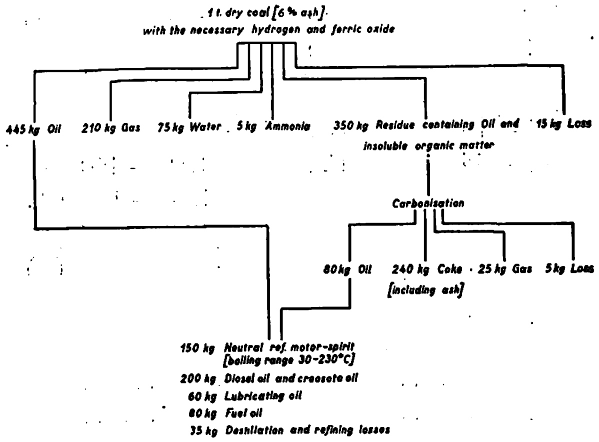

1 t. dry coal [6 % ash]
with the necessary hydrogen and ferric oxide
445 kg Oil
210 kg Gas
75 kg Water
5 kg Ammonia
350 kg Residue containing Oil and insoluble organic matter
15 kg Loss
Carbonisation
80 kg Oil
240 kg Coke [including ash]
25 kg Gas
5 kg Loss
150 kg Neutral ref. motor-spirit [boiling range 30-230°C]
200 kg Diesel oil and creosote oil
60 kg Lubricating oil
80 kg Fuel oil
35 kg Destillation and refining losses

DIAGRAM SHOWING AVERAGE YIELD BERGIUS PROCESS

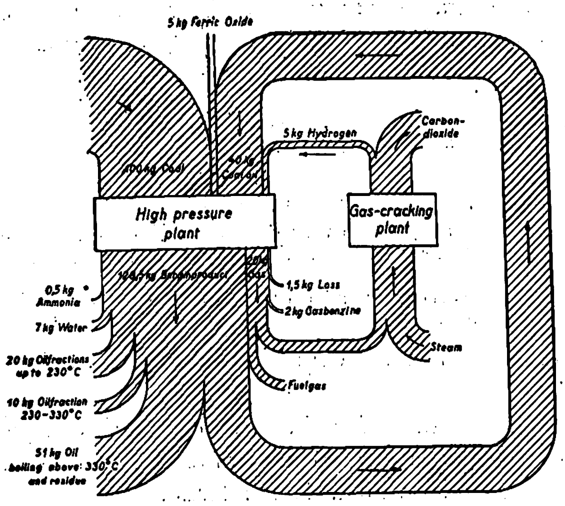
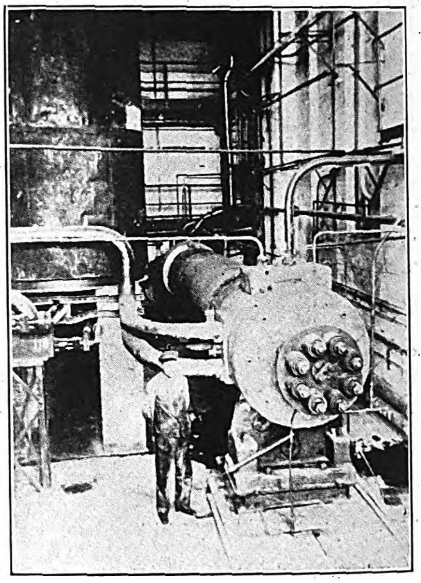

5 kg Ferric Oxide
100 kg Coal
40 kg Carbon
5 kg Hydrogen
Carbon-dioxide
High pressure plant
Gas-cracking plant
2 kg Gas
1,5 kg Loss
2 kg Gasbenzine
0,5 kg Ammonia
7 kg Water
20 kg Oilfractions up to 230°C
10 kg Oilfraction 230-330°C
51 kg Oil boiling above 330°C and residue
Steam
Fuelgas

DIAGRAM ILLUSTRATING CONTINUOUS OPERATION OF A BERGIN PLANT

He pumps a pasty mixture of coal with oil into a cylindrical steel reaction vessel (30 inches diameter, 26 feet long) at 2,200 to 3,000 pounds pressure and 400-500 deg. Centigrade, with a small amount of iron oxide and an excess of hydrogen gas. The latter need not be pure hydrogen but may be a mixture containing hydrogen, provided the latter is in sufficient concentration. The reaction, while in some degree catalytic, depends more upon the pressure of the hydrogen than upon the presence of catalytic material.

The temperature must be kept down (below 500 deg.) to minimize carbonization. A special heating system, for close control and for avoiding superheating of the heavy metal walls, provides a circulation of heated inert gas such as nitrogen, under high pressure, in a jacket around the reaction chamber. This avoids also direct contact of the corrosive reaction products with the heavy walls. A heat exchange system transfers the heat of the exit gases to the gaseous heating medium.



THE REACTION CYLINDER BERGIN PLANT

Special high-pressure valves and stuffing-boxes have been developed to pass the reaction mixture into and out of the vessel. The mechanical energy of the high-pressure out-going gas may be recovered in suitable engines. The exit gas is of high calorific value and may be sold in the compressed state if the demand exists.

The exit gas, containing much methane and ethane, may, however, be converted, by passing over catalytic material, with steam, at 1100 deg. cent. into a gas rich in hydrogen, and used over again in the process. Economy thereby is attained in avoiding the further use of coal or coke to make hydrogen.

Any kind of coal or lignite, except the real anthracites, can be liquefied by this process. With ash in the coal not exceeding 10 per cent, the yield of total oils varies from 40 to 70 per cent on the coal, depending on its kind. The net yield, allowing for auxiliary coal used, is about 30 to 55 per cent. If the by-product gas is sold and not re-circulated (after conversion) the net yield of oils is still further reduced owing to the requirement of coal for making the hydrogen needed. Cheap grades of coal may be used, if not too high in ash.

About half of the nitrogen of the coal is converted into ammonia (more than twice the yield obtained in ordinary coal carbonization), and the sulphur is converted chiefly into hydrogen-sulphide.

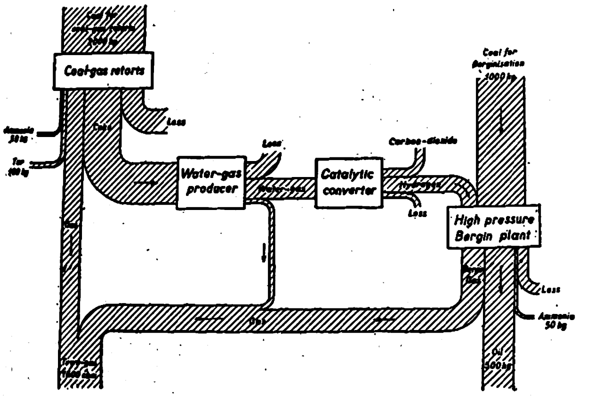


FIGURE 4. DIAGRAM ILLUSTRATING COMBINATION OF COAL GAS PLANT WITH A BERGIN PLANT

The process may be used in combination with gas-works (Figure 4). Coke from the ovens or retorts is made into water gas, which is then in part converted by catalytic treatment into hydrogen-rich gas for the "Bergin" liquefying plant, and in part used for diluting the rich "Bergin" gas obtained as a by-product. The gas send-out is thus made up of retort coal gas, water gas and "Bergin" gas. The gas yield from such a plant is materially higher, and the oil and tar yield almost four times that of a retort or oven plant. It would permit flexibility in operation, the liquefaction plant being used at off-peak periods in the demand for gas.

Two German factories, with a combined output of 1,000,000 bbls. of oil products per year, are under construction. A trial plant, on a semi-industrial scale, is being built at the British Government Station for Fuel Research.

The Synthesis of Petroleum

(By Fischer's Method)

German Patent 293,787 had been issued in 1913 to the Badische Anilin und Soda Fabrik for hydrogenation of carbon monoxide at high pressures with the aid of catalysts. In this case a surplus of carbon monoxide was used, and a mixed product obtained of which the oily layer was made up chiefly of hydrocarbons.

Fischer and associates, at the Institute for Coal Research, Muhlheim-Ruhr, elaborated this process, working at high pressures, but used, rather, an excess of hydrogen and, as contact substance (catalyst), an alkalized iron. They obtained thus in the oily layer of the condensed product, not hydrocarbons, but a mixture of higher alcohols with various other compounds, which they called Synthol. It could be used as motor fuel direct or could be partly converted into hydrocarbons by suitable catalytic treatment. The reacting gases required purification from sulphur.

In contrast to this high pressure method, Fischer has recently developed a process working at ordinary pressure and at temperature of 200° - 300° cent., wherein technical water gas, purified, is passed over a cobalt or iron catalyst and a product of higher hydrocarbons obtained. The formation of methane is avoided by keeping the temperature below 300°. Hydrogen sulphide in the reacting gases interferes by greatly retarding the catalytic action and other sulphurous gases have a similar but lesser effect. The "fixed" sulphur compounds in the gas may be greatly reduced by a special catalytic treatment devised by the authors.

In one passage, about 50 per cent of the carbon monoxide is converted. The residual gas may then either be circulated again or be sent out for public consumption. The yield of liquid and solid hydrocarbon product, so far obtained, is about 100 grams per cubic meter of water gas, after several passages over the catalyst. This corresponds to about 6¼ pounds per 1000 cu. ft.

The products may be fractionally condensed and require little, if any, secondary refining. A portion of the oils is recovered by absorption of their vapors from the gas by activated charcoal or silica-gel.

The Production of Methyl from Water Gas

(Patart)

The paper of General Patart describes researches which have developed a practical process of producing methyl alcohol, and, under certain conditions, of higher alcohols, by the action of hydrogen upon carbon monoxide, under high pressures and temperatures in the presence of certain catalysts.

With the temperature held closely at 350° - 400° cent. and a suitable catalyst (best a mixture of zinc and chromium oxides), practically pure methyl alcohol can be obtained in the first product. At higher temperatures, mixtures of higher alcohols (such as iso-butyl) are obtained, and these are better adapted to use as motor fuel than is methyl alcohol itself. This mixture may be partially converted into hydrocarbons by catalysis over alumina.

The partial pressure of the reacting constituents in the gases, namely, hydrogen and carbon monoxide, is of the highest importance in determining yields and rate of production. The percentage of inert gases must, therefore, be minimized.

Iron and nickel are to be avoided in the surface metal of the reacting vessels and tubes of the heating coils for the gases. Copper, aluminum, chromium, or a suitable glaze not attacked by the gases, are permissible.

The process could well be applied to water gas and made an adjunct of gas works, wherein a portion of the water gas make (using the parts of the run that contain least methane and nitrogen), are passed through the pressure synthesis. The "purge gases" may be returned to the generator during other parts of the "make" period, and serve to enrich the gas with methane.

In this way 2.5 cu. meters of water gas will yield 1 kilogram of methyl alcohol and 4.2 cu. meters yield 1 kilogram of iso-butyl alcohol. This is equivalent to 2 kilograms of coal used for 1 kilogram of methyl alcohol, and 3 kilograms of coal per kilogram of iso-butyl alcohol.

The author estimates, under favorable conditions, in the United States, a production cost not exceeding 20 cents per gallon of methyl alcohol, including amortization of plant; cost of plant and equipment for production of 20 tons of methyl alcohol per day, not to exceed $400,000—$500,000.

Low-Temperature Carbonization of Coal

The fundamental difficulty in carbonizing coal at low temperatures is in transferring heat to the coal in a reasonably short time when a relatively low-temperature gradient is used. Coal is a poor conductor of heat. It takes much longer to transfer the necessary amount of heat through a given volume of coal when the retort walls are at a temperature of 500°C. than when they are at 1,200°, as in the usual high-temperature process. As the cost of the operation depends in a large degree upon the installation charges per ton of coal carbonized, it becomes necessary to accelerate the rate of carbonization, either by spreading the crushed coal in a thin layer on a heated surface or by agitating the coal, bringing fresh portions continually in contact with the heated walls, or by passing large volumes of hot producer gas, products of combustion, or superheated steam through the mass of broken coal.

Differentiated on the basis of method of heating, the various processes fall into two classes, namely, externally heated retorts in which the coal to be carbonized is supplied with heat through the walls of the retort and the products of distillation are not diluted with flue gases; and internally heated retorts in which the coal to be carbonized is heated by direct contact with hot gases or superheated steam passed through the retort in intimate contact with the charge.

Carbonization processes may be intermittent, those in which the coal is charged into an empty retort and remains there until distillation is completed, when the entire mass of coke or residue is discharged at one time; or they may be continuous, those in which charging and discharging are continuous or in small increments.

Present high-temperature processes of by-product coke making are intermittent, because intermittent processes generally produce firm and lumpy coke. Continuous vertical retorts are coming into considerable use in the gas-making industry because continuous processes favor larger outputs and cheaper operation. The coke, however, has physical properties somewhat inferior to those of coke produced by intermittently charged retorts.

As to the style of construction, retorts may be classified as follows: Oven types, usually of rectangular shape, as the standard by-product oven; vertical shaft types, as the vertical gas retorts or the Scottish oil-shale retort; and rotating-cylinder types, vertical, horizontal, or inclined, similar to revolving driers or cement kilns; the cylinder type may also be stationary and have a revolving internal stirrer.

Short Wave Radio Transmission

The problems of radio communication which arise when short waves (less than 150 m.) are used are so different from those involved in the usual broadcast range of wave lengths that the casual "broadcast listener" can have no conception of them. For example, a so-called "skip-distance" occurs, which no reception is obtained beyond the immediate neighborhood of the transmitter until a distance of several hundred miles is reached when very strong signals may be found. Daylight may afford better reception than night and fading problems are very different. An account of an investigation of these problems by Messrs. Heising, Schelling and Southworth has been published by the Bell Telephone Laboratories under the title "Some Measurements of Short Wave Transmission." C. W. B.

Loading for Telephone Cable Circuits

Long distance telephony and submarine cable telephony have in part at least been made possible only by "loading" the conductors. Loading is a means of neutralizing the natural electro-static capacity of a circuit by inserting inductances at the proper intervals. In order to accomplish this successfully, it was necessary to develop a new form of core material for the inductance coils. This consists of finely powdered iron and the particular advantage lies in its very uniform permeability which can be made to have any desired value. A short but rather complete account of the various elements involved in cable telephony is contained in a pamphlet by D. W. Whitney of the A. T. & T. Co. C. W. B.

Metering of City Water Supply[*]

By SETH VAN LOAN

Deputy Chief, Bureau of Water, Philadelphia

SECONDARY to none of the links of a Water Works is its distribution system. There are sections in municipalities and large towns where service is expected from sub-surface utilities the age of which compares with the development of areas at some early period.

Changes in character of service and increasing demand from the utilities, require enlargements and more flexibility of flow. Cities of an age and development character such as Philadelphia, have been confronted and are still facing a radical change in topography throughout various areas. Hotels, apartment houses and office buildings are occupying the same space formerly held by three and four-story residences. At times water to the older sections was formerly delivered heavily charged from its source with suspended matter. The introduction of filtered water extended over a period of twelve years, but in no way did the clear water scour or remove the sediment in mains throughout the old areas. Carrying capacities had been reduced and additional piping was needed to supply the reasonable demand of both house-holder and commercial interest. As new lines were laid many of the abutting consumers desired their connection transferred to the clean piping, but the greater number continued on the original lines.

The functioning of a distribution system depends vitally upon the water circulation through the mains, and inspection often reveals the fact that gate valves may be the offender on restriction of flow. Throughout the Philadelphia system there are 42,000 stop valves, of which number there are 40,000 on lines twelve inch and smaller in size. Routine inspection and operation of these gates is one of the dreams of a distribution engineer—but such an accomplishment is seldom realized.

The sub-surface leak that may never appear above the street pavement may be a broken main, a leaky joint, or a defective service connection, the flow from which escapes downward to some sewer; the careless abuse of the utility inside the consumer's property due to failure to keep plumbing in repair, or the unreasonable use of water by some irresponsible agent within the property confines; these three factors tend to a combination of leakage which is enormous and all beyond the vision of the regular outside inspection. An illuminating chart prepared in 1900 by John R. Freeman, eminent hydraulic engineer, is most impressive in outlining by curves the volume of the hourly quantity of water supplied during three (3) days in Manhattan and Bronx, New York City, and is divided into its separate avenues of use and loss. This chart credits on a per diem basis:

To incurable waste	10 gallons
Needless waste	65 "
Doubtful use	15 "
Actual use	25 "
Total	115 gallons

The distribution system of Philadelphia is at the present time enjoying a survey to determine pipe flows and community usage. The large pipe—feeders or express mains—have been under observation during the last year and in some instances there appears a night flow equaling nearly 80% of the maximum daylight draft. Night flows prevail to an extent far beyond the reasonable demand in many of the mains surveyed. Residential sections are offending equally with the industrial areas. The field for adjustment is extensive.

Philadelphia, during 1906 to 1908 inclusive, financed a water waste survey the efforts of which were directed mainly to West Philadelphia. In 1912 a water conservation show was staged, in a place of prominence, and propaganda to save water was launched and kept active for several months. Much light was thrown upon the virtue of meters on water services and a most gratifying start upon their acceptance was made. As there was no compulsion on the part of the city to install a meter, it fell upon the salesman of the respective meter companies to create a business and keep it alive. Inasmuch as the entire expense of installation and cost of meter was born by the consumer, the conversion period from fixture to meter rating lasted for only a few years, after which time the disposition of the consumer blocked the progressive move and approximately 280,000 services are still carried as fixture accounts on the City's books.

City Council passed an ordinance in 1918 requiring the placing of a meter on any new services. During the past eight years the field for meter installations has been represented by the new construction of homes, and buildings representing some commercial interests. The number of accounts on a fixture basis has been reduced due to the old building sites giving way to new construction.

Of the 280,000 fixture accounts there are but 7,200 which are listed above a $25 annual return; approximately 117,000 return from $1 to $9, and 120,000 from $10 to $14. These last 237,000 services represent, al-

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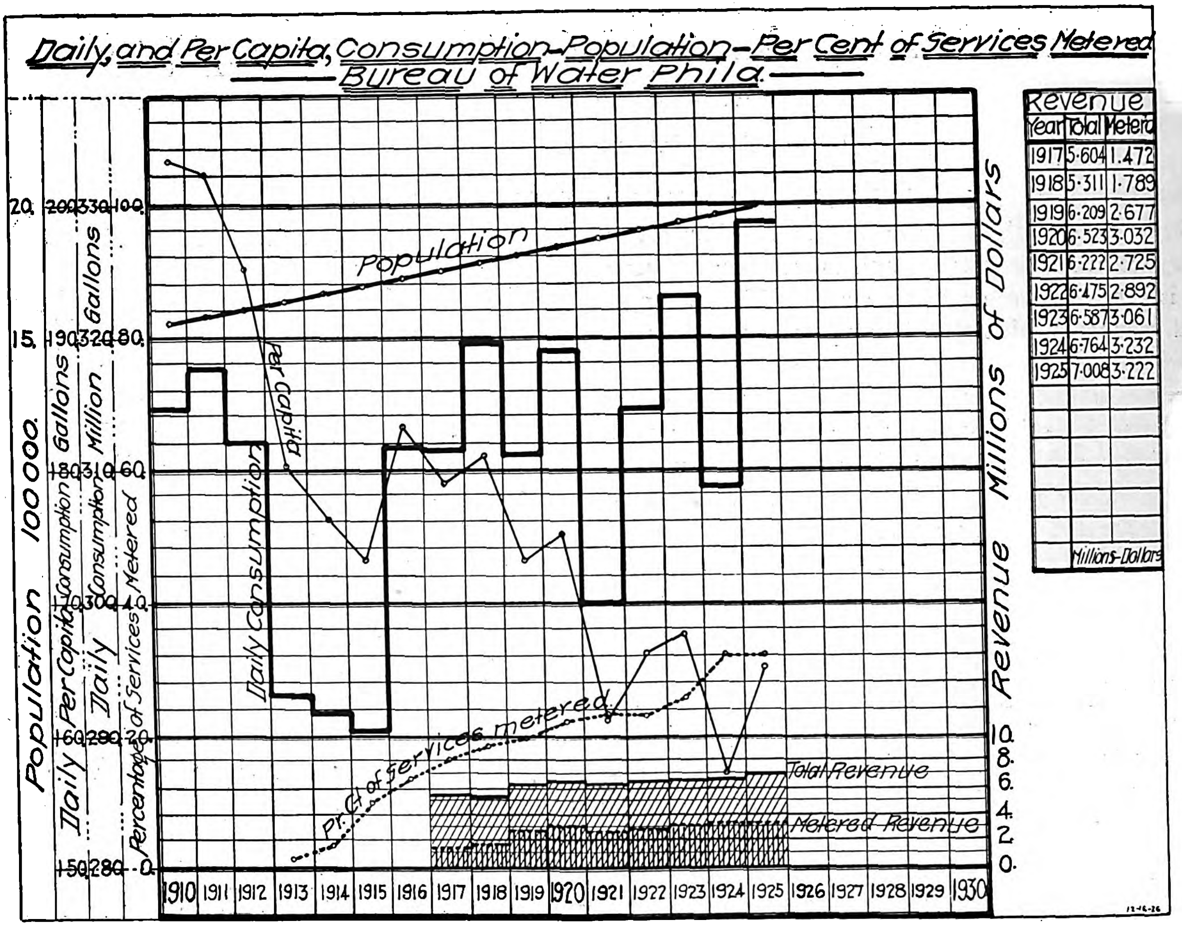
[*] Address before the Engineers Club, December 21, 1926.



Daily, and Per Capita, Consumption—Population—Per Cent of Services Metered
—Bureau of Water Phila.—

Revenue		
Year	Total	Metered
1917	5·604	1.472
1918	5·311	1·789
1919	6·209	2·677
1920	6·523	3·032
1921	6·222	2·725
1922	6·475	2·892
1923	6·587	3·061
1924	6·764	3·232
1925	7·008	3·222
	Millions-Dollars	

most without exception, service to the small store and residence. The enrollment of such under a meter classification is a real problem. Many commercial interests, the existence of which predates the new construction ordinance, were forced to change and use meters through the operation of an ordinance passed by City Council in 1916, and which specified metering of consumers engaged in various types of business.

Many small properties obtain their supply of water from a yard hydrant on their own or an adjacent property. The lowest rate on properties that have such an attachment, or a single spigot inside the house, is $5.00. Much loss of water in past years resulted from a yard flush hopper. For obvious sanitary reasons the seat of this device was frequently securely nailed down causing a constant flow. These hoppers are now prohibited and inspection shows that their use has been discontinued.

The distribution of water regardless of the quantity supplied at the inception of the works, will never be satisfactory where thousands of offending terminals and unknown leakages during transmission exist. The house to house method of water waste control is effective if kept alive but the expense is such that few cities have attempted more than a year's trial and it is doubtful if any maintain an organization for this purpose. For a city the size of Philadelphia and with the procedure as routine, the expense would be prohibitive. The follow up work must be positive and the penalties for lack of leak attention must be enforced.

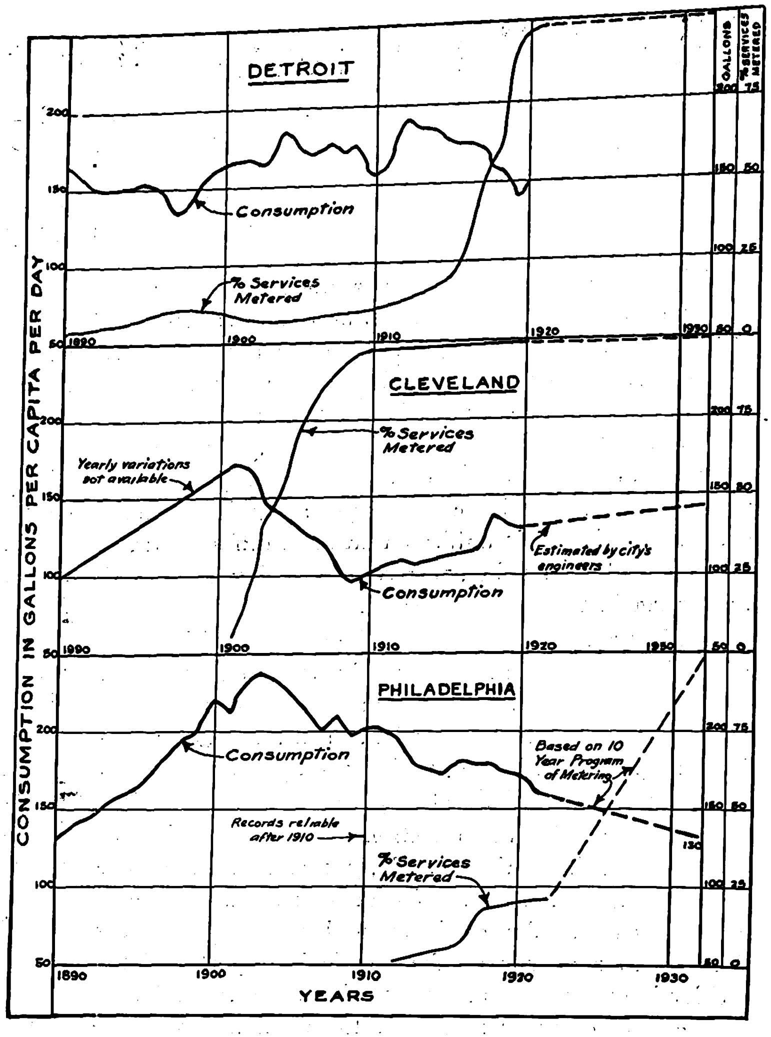
The waste water survey during 1906 throughout West Philadelphia paralleled in time the functioning of the filtered water introduction from the Belmont plant. Much good work was accomplished and corrections of troubles following that survey reduced materially the water consumed. Due to the extensive building and increased requirements in West Philadelphia, it has been again chosen for check up on water waste. This section of the city registers a population of approximately 450,000, its commercial interests are supplied through 83,000 services, of which 40% are metered as against an average of 32% for the entire city. The per capita rate in West Philadelphia shows 110 gallons per day. Primarily this is a residential section yet such plants as the P. R. R. yards, Brill Car Works, General Electric Co. and various laundries add materially to the draft on the system. The entire city shows a rate of 168 g.p.d. but in considering this figure it must be remembered that Philadelphia is distinctively a manufacturing center. Thousands of residents in West Philadelphia have employment elsewhere during their day. Further light will be shed on use of water in this wide area at an early date as activities of the survey are now being directed to clean up the waste water.

The following list shows per capita rate and per cent of metered services in a few of the larger cities.

City	Population	Per Cent Metered	Per Capita
New York	5,927,000	27	131
Chicago	2,886,000	10	275
Philadelphia ..	1,922,000	28	165
Detroit	1,130,000	99	133
Cleveland	888,000	97	142
Los Angeles...	667,000	99	140
New Orleans..	404,000	100	110
Buffalo	537,000	14	220
St. Louis	803,000	8	140
Louisville	258,000	12	133

The outstanding exceptions—the last two cities—a low consumption combined with a low percentage of metered services may be accounted for in Louisville by the character of the city and a waste water survey at the time of the introduction of a filtered supply of water. At St. Louis the department maintains a branch in its organization assigned to pitometer work and quarterly valve inspection.

The accompanying diagram shows, with the population of Philadelphia, a daily consumption and per capita curve. The percentage of metered services with their corresponding revenue return may likewise be traced. The total money return may be noted—this amount including also funds from sources other than for fixture and metered services.



Gentlemen, you are engineers and have a practical mind; you are engaged in design and construction; you are educated to combine form and stability with economy. Many of you are associated in an advisory capacity with utility companies and industrial interests and are familiar with the problem of supply and demand. As citizens and taxpayers you are stockholders in a big industrial plant—a municipal water works system—supplying a utility and furnishing a vital commodity, which should be paid for on a well established unit basis. Your benefit through this investment in an ample supply of water at a reasonable rate, and your dividend is the difference in the amount you will pay and that which you now are required to pay in order to supply an overdraft of from 10 to 15 per cent to every man, woman and child in the city of Philadelphia. The Bureau of Water is, at present, engaged in a water waste survey and it is doing its part to correct underground leakage in its distribution system. An equal responsibility bears upon the consumer to correct the inside leaks. To you, gentlemen, and to all consumers, the water works engineer appeals—to meter and to meter universally.

The U. S. Supreme Court and Public Utility Valuation

By **JOHN B. GEST**

Member of the Philadelphia Bar

THERE are few intellectual wildernesses so trampled by pathless wanderers as the so-called field of public utility regulation. Here the engineer, the lawyer, the economist and the financier are free to roam. Each believes the blazing of the trail rests with him and each is apt to go his own way, or perhaps in many cases the wayfarer cares little for marking a trail but is rather in search of private gain. Whatever the motives it is unlikely that such different travellers would follow the same course or that all would be headed in the same direction.

A big man's intellect will often outstrip his early education, and the little fences between engineering, legal and commercial thought are often passed as advance is made in any profession. But still such problems as public utility regulation are apt to be viewed from a professionalistic standpoint.

For example, the question of the deduction of depreciation from the rate base means to the case hardened lawyer a study of what courts have done in decided cases. An engineer will probably address himself to a survey of the physical property of the utility in order to form a conclusion as to the deleterious effects of wear and tear, the elements, and the neglect of repairs and renewals. The accountant may view the problem as one dependent upon the system of keeping books, and the term "depreciation" as conceived in his mind is rather a paper liability than a physical fact. The financier will probably be interested in the protection of the investment and the past, present and future return to the owners. It is small wonder then that the Supreme Court has delayed the formulation of a rule for fixing value for rate making purposes, and has contented itself with stating only in very general terms the matters which must be considered in determining value.

The Supreme Court was not obliged to consider the factors entering into the rate base prior to 1898. In the cases before that date in which it held rates to be so low as to confiscate property, in violation of the Constitution of the United States, the rates were insufficient to meet operating expenses. But the day could not be postponed and a consideration of what constitutes fair value was precipitated in Smyth v. Ames.[1] Here stockholders in the Union Pacific, Chicago and North Western, and C. B. & Q. were protesting against rates fixed by a statute of Nebraska. William Jennings Bryan argued for the State and we may imagine with what force the eloquent champion of the people's rights argued that the court had no right to pass on the reasonableness of the profit remaining to the stockholders after paying operating expenses, but that in case it had this right then "the present value of the roads, as measured by the cost of reproduction, is the basis upon which profit should be computed." Whether or not it was a reflection of the brilliance of the orator's argument, or of the innate soundness of the rule, the court decided that a fair return must be allowed on the fair value of the property, and that in determining value for rate making purposes various factors must be considered, including the original cost, and "the present as compared with the original cost of construction."

The court mentioned other matters to be considered, but after removal of dunnage and spare parts the rule of this case is broadly that both original cost or investment,[2] and cost of reproduction were to be considered in fixing value.

Needless to say, in that case cost of reproduction was less than investment. Now the tables have turned. They had turned to some extent in the Minnesota rate case[3] where Justice Hughes said "It is clear that in ascertaining the present value we are not limited to the consideration of the amount of the actual investment. If that has been reckless or improvident, losses may be sustained which the community does not underwrite. As the company may not be protected in its actual investment, if the value of its property be plainly less, so the making of a just return for the use of the property involves the recognition of its fair value if it be more than its cost." Like all good rules (and some others), the rule of Smyth v. Ames works both ways, and reproduction cost was thereafter to be considered in determining value in cases where it is higher than investment as well as when lower. Thus the argument which first appeared against the utilities was adopted by them, and undoubtedly saved some from disaster in the period of inflated prices following the war when expansion was vital and a cost of reproduction rate base was necessary in order to attract capital.

It is not the purpose of this article to pass judgment on the many interesting arguments for or against cost of reproduction. The reflection of all the numerous arguments on both sides can indeed be found in the mystic maze of Commission and Court decisions but the Supreme Court of the United States has not departed from the rule of Smyth v. Ames, nor has there been a crystallization of any definite rule as to the relative weight to be assigned the different elements of value to be considered. This is clear upon a glance at some of that Court's most recent decisions.

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[1] 169 U. S. 466.

[2] This discussion is not concerned with differences between original cost and investment due to reinvested earnings, or to irregular handling of capital, etc.; nor with the various theories of depreciation.

[3] 230 U. S. 352, 1912.

In Missouri ex rel Southwestern Bell Telephone Co. v. Public Service Commission, decided May 21, 1923, the Public Service Commission of Missouri had valued the telephone properties in the state, as of 1919, by adding the cost of subsequent additions to previous valuations made by the Commission in 1913, 1914 and 1916. This, of course, took no account of the increase in costs between such dates and 1919, which amounted to about 50 per cent. Mr. Justice McReynolds, who wrote the opinion reversing the action of the Commission, epitomizes the theory of the court in the neat aphorism "Estimates for tomorrow cannot ignore prices for today."

Sometimes it is thought that the publication of dissenting opinions jeopardizes the prestige of the Court—but there is something intensely American, or Anglo Saxon, or Nordic, or some other adjective that means that you and I are better than the rest of mankind, in the triumphant defiance of our minority judges, who are "down but never out." And, too, very valuable contributions to legal science, if such a thing is extant, are often made in the form of dissenting opinions.

Mr. Justice Brandeis wrote a concurring dissent in the Southwestern Bell case in which he was joined by Mr. Justice Holmes. This means that the judge goes to the same place as the Court but by a different route. Brandeis' opinion is a masterful writing on the subject of valuation, and the reading of it is well worth even an expert witness' time. His theory that "prudent" investment should be adopted as the rate base is not the law—in fact its universal adoption now would work injustice in many cases of old utilities—but his reasoning is entitled to study, and his statement that "The so-called rule of Smyth v. Ames is, in my opinion, legally and economically unsound" may be echoed in some majority opinion in the future.

Within three weeks of this decision the Supreme Court in Bluefield Waterworks and Improvement Company v. Public Service Commission[4] reversed a decision of the West Virginia Commission which had used previous valuations of 1915 brought to date of 1920 by adding capital additions at cost. The report of the commission in the 1915 case showed clearly that investment was used as the rate base in that case, and the Supreme Court in an opinion by Mr. Justice Butler found that "the commission, in arriving at its final figure, did not accord proper if any weight to the greatly enhanced costs of construction in 1920 over those prevailing about 1915, and before the war——." This decision harmonizes with the Southwestern Bell case and cites Smyth v. Ames with approval.

The Atlanta Gas case, Georgia Railway and Power Company v. R. R. Commission of Georgia,[5] was decided on the same day as the Bluefield case and served to correct the impression that the Supreme Court had approved "slavish adherence to cost of reproduction, less depreciation"[6] in fixing the rate base. Here the Commission in 1921 valued so much of the property as was in existence January 1, 1914 (most of the plant), at substantially its actual cost. Construction costs were about 70 percent higher in 1921 than in 1914, and the Company claimed that the property should have been valued at the cost of reproduction prices. It appears that the only "unearned increment" allowed in fixing value was an appreciation of $125,000 in the value of land. The value fixed by the Commission was $5,250,000. The Company claimed $9,500,000 on cost of reproduction basis.

Mr. Justice Brandeis, having shot his bolt on prudent investment in the previous case, wrote the majority opinion on the Smyth v. Ames theory, and supported the decision of the Commission, saying "The case is unlike Missouri ex rel Southwestern Bell Telephone Company v. Public Service Commission. Here the Commission gave careful consideration to the cost of reproduction, but it refused to adopt reproduction cost as the measure of value. * * * The refusal of the commission and of the lower court to hold that for rate making purposes, the physical properties of a utility must be valued at the replacement cost, less depreciation, was clearly correct."

Mr. Justice McKenna dissented believing this decision to conflict with the two preceding cases. Certainly this is a subject on which not every man, no not every judge, is presumed to know the law. Will a statement by the commission that it carefully considered reproduction cost be sufficient? Or does the allowance of appreciation in land value show sufficient consideration? Or was Justice McKenna right? In answering these questions there is this to be kept in mind. In the first two cases there had been previous commission valuations. Since those valuations must depend on a consideration of cost of reproduction, any change in this factor should change the valuations; and if the previous valuations stand unchanged except by the addition of new capital expenditures it follows that the upward swing in cost of reproduction was not considered. In the third case it was an original valuation and it was apparently felt by the majority court that sufficient consideration of cost of reproduction was shown in the allowance of land values. If this was the theory it is probably reconcilable with McCardle v. Indianapolis Water Company, decided November 22, 1926.[7]

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[4] 262 U. S. 679.

[5] 262 U. S. 625.

[6] Language used by lower court quoted by the Supreme Court.

In the latter case the Indiana Public Service Commission had fixed rates for the Indianapolis Water Company by order effective January 1, 1924, reporting the value of the operative property of the company to be $15,260,400. This was based on a previous valuation as of December 31, 1921, brought to date by adding subsequent capital additions at cost. The previous valuation adopted outright cost of reproduction less depreciation at average prices over a period of ten years ending December 31, 1921. The lowest estimate of "spot" price cost of reproduction less depreciation as of January 1, 1924, was $19,500,000, without, however, including water rights and going value which brought it to over $21,000,000.

The District Court granted an injunction against enforcement of the Commission's rates. The district judge seemed to feel obliged under the three cases discussed above to adopt "spot" price reproduction cost less depreciation as the rate base, and found the value to be not less than $19,000,000, which figure he believed represented the lowest possible estimate at spot prices.

The Supreme Court in an opinion by Mr. Justice Butler, with Mr. Justice Brandeis again dissenting, and Mr. Justice Stone with him (not, however, on the prudent investment theory) affirmed the District Court decision and found the value to be not less than $19,000,000 without, however, approving the reasoning suggested in the language of the district judge. It declared that "While some expressions of the district judge indicate that he was of opinion that dominant or controlling weight should be given to cost of reproduction less depreciation estimated on spot prices as of January 1, 1924, it is clear that the $19,000,000 fixed by him as the minimum value could not have been arrived at on that basis." It is then shown that the minimum figure at spot prices after inclusion of water rights and going value was $21,051,000 and that the company's estimates were considerably higher. And the court reaffirms the Smyth v. Ames rule, saying, "The decision of this court in Smyth v. Ames declares that to ascertain value 'the present as compared with the original cost of construction' are, among other things, matters for consideration. But this does not mean that the original cost or the present cost or some figure arbitrarily chosen between these two is to be taken as the measure. The weight to be given to such cost figures and other items or classes of evidence is to be determined in the light of the facts of the case in hand."

The valuation previously made in 1921 on ten-year average prices had been used as the rate base, except for adding new property and some minor changes. The Supreme Court said: "The high level of prices and wages prevailing in 1922 and 1923 should be taken into account in finding value as of January 1, 1924, and the years immediately following." This case is substantially in harmony with the Southwestern Bell and Bluefield decisions, although it goes farther in making a definite finding of the effect of increased prices on the rate basis. The trained ear, however, distinguishes a note of discord when this case and the Atlanta Gas case are sounded together, unless indeed they can be reconciled on the ground that one is based on a former valuation, the other on a new one.

It has not been attempted in this short discussion to wade through the eddying current of Court and Commission cases, but to pass lightly over the stepping stones laid by the Supreme Court, for it is that body which must eventually choose the best of legal, engineering, and financial thought and formulate more definite rules. The tremendous post-war spread between cost of reproduction and investment in our established utilities has been prolific of much confusion and litigation. "Gentlemen may cry peace, peace—but there is no peace," as long as utilities and public can sincerely advance such widely differing measures of value as the rule of Smyth v. Ames allows. There is no peace as long as the law appears to require fixing a rate base before determining fair return, when justice often requires first considering the capital structure of the utility, the amount of interest and discount on its indebtedness, and the past history of its depreciation and dividend accounts—and their going into reverse to find fair value.

The prospect for clarifying the law, however, is bright. Many utilities having ridden over the crest of the recent wave of prices on the reproduction cost theory, are abandoning it, faced as they are with the prospect of being swamped in the trough of the wave, if that theory should become too firmly fixed and a further decline in prices should follow. And undoubtedly, as expansion in the utility industry takes place at post-war prices, investment and reproduction cost figures will, in many cases, more and more approach each other, accounts will be available, and the laborious estimates of cost of reproduction will pass out of the picture. This will mean not only the saving of time and expense of litigation, but the releasing for productive work of a wealth of the intellectual resources of the utilities. And our professional explorers can join forces and cut their way through the thicket to the discovery of a more definite rule for finding value fair to all parties.

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[7] 47 Sup. Ct. 144.

The Business Situation

A "WAITING attitude," perhaps best describes the position at present taken by the leaders of many industries. In some lines of work there appears to have been a definite improvement in sentiment, in fact, to such an extent that plans for increased activity are taking definite form. Releases received from various financial institutions are rather more definitely optimistic than a month ago.

What Colonel Ayres Thinks of 1927.

Colonel Leonard Ayres of Cleveland has a well-earned and widespread reputation as a forecaster of business conditions. Year after year he reviews the year ending and makes public his estimate of the year to come. And year after year he proves to be so close to the mark that his mistakes are only about enough to make him seem quite human.

Experience has shown that when Col. Ayres forecasts turn out in any sense inaccurate they are less favorable than the actual conditions prove to be, as the months come and go. One who trusts the Ayres estimates of business in the year ahead too implicitly and with too much attention to precise details is agreeably surprised now and then, but seldom if ever disappointed.

The following generalizations are from his annual address before the Cleveland Chamber of Commerce:

Interest Rates—Probably irregular but slightly declining.

Bond Price—Probably rising.

Stocks—Selectively irregular without any real bear or bull movement but with a tendency of certain stocks to reflect their then earning powers from month to month.

Building—Somewhat reduced in volume. Costs not so high but with reductions more noticeable in materials than in labor.

Living Cost—Slightly downward trend.

Wholesale and Retail Prices—Slowly moving off.

Iron and Steel—Somewhat lessened demand from building industry but great demands of railroads.

Automobiles—No sharp restriction in output—probably 95 per cent of the 1926 total.

Industrial Profits—Near those of 1926, but slightly less.

Railroads—Real and generous prosperity.

Rubber—A good year.

Installment Buying—No important results for good or ill.

In closing his address he said: "To repeat the figure of speech I used a year ago: In 1927 we may proceed with somewhat reduced speed but with no need for second gear. We may have some worries but no blowouts, some skipping, but no serious engine trouble. We may expect some downward turns but no skidding on those turns."

The Guaranty Trust Company of New York in its latest survey writes: "While many branches of trade are still under the influence of the year-end recession, and reports indicate that activity in some lines has not thus far revived as promptly as was expected, it is still too early to conclude that this tendency has any significance as an indication that the year's business may be materially less active than that of 1926; although this view finds some support in the unexpectedly sharp downturn experienced by a number of lines in the closing weeks of last year.

Financial Conditions Favorable

"Without question, the outstanding trend in financial markets during the last few weeks has been the downward movement of money rates. While some easing is always expected after the passing of the temporary demand for year-end accommodation, the present movement is generally regarded as distinctly more pronounced than could have been expected on the basis of purely seasonal influences. The decline may be interpreted as a reflection of lower business activity and of a general expectation that the demand for commercial loans in the near future will be on a reduced scale, or it may be regarded as a natural result of the net addition of some $90,000,000 to the country's gold supply during the past year. In either case, the lower rates will tend to arrest any marked decline in trade activity from the high levels maintained during the last two years.

"The most conspicuous feature of the financial situation of the country as a whole is the complete absence of the credit strain which usually follows a long period of high business activity. There is an abundant supply of bank credit for commercial needs, while funds for long-term investment are larger than ever before and are growing constantly. Call money rates declined from 6 per cent on December 31 to 4 per cent in the third week of January. In spite of the high business activity of the last twelve months, the large amount of funds employed in security markets and the growth of commercial loans and of installment sales, the total volume of credit required of the Federal Reserve banks is actually smaller than a year ago. This means that the banks are not drawing upon their ultimate reserves and that these can be used to meet increasing demands for commercial funds or to preserve the soundness of the financial structure in the event of possible trade reaction.

"This underlying strength of the credit situation is primarily due to the rapid growth of the banking capacity of the United States in recent years. The bank expansion during the last four years has exceeded even the tremendous increase that was neecssary to finance the war.

Relative Decrease in Commercial Loans

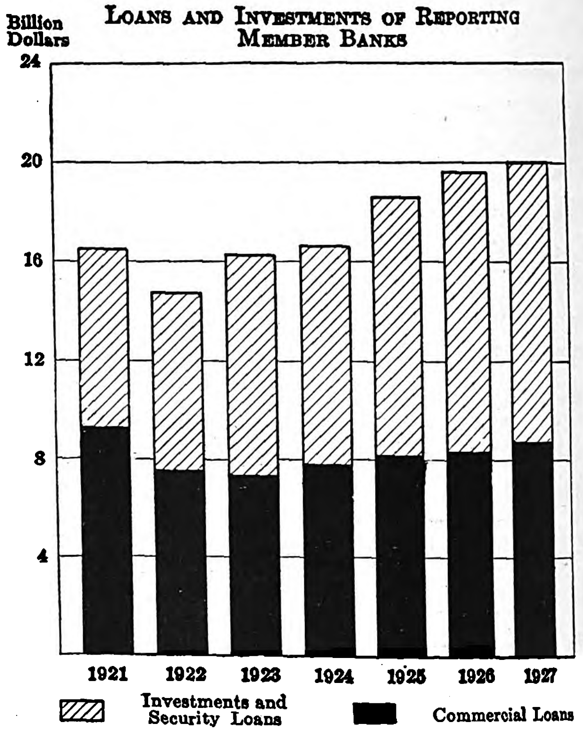
"The declining price level has made it possible to float the same physical volume of business on less bank credit. In the absence of rising prices there has been little or no speculation leading to the accumulation of inventories, and consequently no expansion in the demand for bank credit with which to carry commodity stocks. The better organization of transportation has reduced the amount of capital required for financing goods in transit, and at the same time has stimulated the tendency toward hand-to-mouth buying which has resulted in such important economies in the use of short-term credit. Furthermore, the growing tendency of many corporations to finance their recurring short-term requirements through the sale of bonds, notes and capital stock has, on the one hand, reduced the supply of commercial bills and, on the other, increased the demand of the public for loans against security collateral.

"These developments have created a situation which has not been sufficiently appreciated, and which requires care lest it assume serious proportions. Faced with a plethora of funds and a relative scarcity of commercial bills, the banks have been forced to employ their resources in security investments and in loans to customers secured by stocks and bonds. This increase in bank investments and loans on securities without a corresponding gain in holdings of short-term commercial bills has resulted in a decline in the proportion of banking assets eligible for rediscount with the Federal Reserve banks and consequently in a less liquid condition of banking assets as a whole.

Strength of Banking Situation

"The banks, however, are in a stronger position than a year ago. Total borrowings of the reporting member banks were $44,000,000 smaller at the beginning of this year than on the corresponding date in 1926. The Federal Reserve system has a vast reservoir of credit at its disposal, which can be used to meet any reasonable demand for commercial funds, to provide for any probable demand for gold from abroad, without serious restriction of the domestic credit supply, and to prevent the occurrence of any severe financial embarrassment as a result of possible business recession.

"In 1926 the dominant factors in the money market were, first, economy in the use of commercial credit as a result of a declining price level, hand-to-mouth buying, small inventories and record-breaking transportation facilities; and, second, the very large resources of the Federal Reserve system. At the opening of this year there is no indication of a sudden or drastic change in any of these factors. It is reasonable, therefore, to suppose that money rates will remain easy at least in the near future."



The National City Bank of New York

The following extracts are from its February Bulletin:

"The commonly accepted measures of business indicate that the country has made a good beginning on the new year. Trade has not started off with any great rush, but there has been a good upturn after the quiet period at the year-end and business is moving steadily in most lines. It is recognized as too early to gauge the tendencies of the year with much accuracy and the attitude of business generally is one of making haste slowly until the course of spring industry and trade is more clearly defined.

"Repeatedly since 1922 a wave of pessimism has spread over the country, having its origin each time apparently in apprehension that capacity to produce is so much in excess of our ability to consume that after a brief 'spell' of prosperity we must of necessity have a period of depression while an accumulated surplus is being worked off. A year ago, it will be recalled that business had the same doubts about the forthcoming year that are now being expressed in some quarters relative to 1927, but business belied the pessimists by going on the new heights of prosperity.

"The situation at the outset of 1927, it must be admitted, is not quite the same as at the outset of a year ago. We have had one more year of very heavy building operations which must of necessity bring us nearer to the time when building operations will undergo some decline. We have also had another year of heavy production in the automobile industry with indications that that industry also may not be able to continue without some interruption in its record of year to year increases. Moreover, the decline in agricultural prices, particularly in the case of cotton, tends likewise to disturb the equilibrium of business.

"In certain other fundamental respects, however, the situation has not changed. The dominant sustaining factor continues to be the case of the credit situation.

"Low money rates are rising bond prices such as we are now witnessing, and which have carried representative bond averages to the highest levels since pre-war, are not among the usual harbingers of depression. Stimulated by a favorable bond market, new capital issues continue in record-breaking proportions, and each one of these issues represents funds definitely ear marked for expenditure in the employment of labor or purchase of materials for construction and equipment of some kind.

The Threatened Coal Strike

"One of the major problems which the country will have to face this Spring will be the conclusion of a new wage agreement in the bituminous coal industry. The present wage agreement between the operators and union miners, concluded three years ago at Jacksonville, Florida, expires April 1, and operators' and miners' representatives are to meet in joint conference February 14 to frame a new agreement. The old scale provided for the maintenance of wages at above the war-time peak and resulted in severe losses and much unemployment in the union fields owing to the competition of non-union coal mined under lower wage rates. How large this disadvantage has been may be seen by comparing the non-union scale of about $4.40 a day for unskilled labor with the union scale of $7.50. As a matter of fact, only in unusual periods such as during the high prices caused by the British coal strike has the scale of the Jacksonville agreement been generally effective.

Oil Outlook Good

"Contrasting with the beclouded outlook in the coal industry, prospects for the oil companies are regarded favorably. Production of petroleum has been running at very high levels recently but is not viewed with alarm, because of record-breaking consumption. Moreover, there are indications that production in the Seminole field, which has contributed most to flush output, is close to or at peak."

R. G. Dun & Co.'s Review

More definite evidence of expanding operations appeared in the closing week of January, though the general level of commodity prices was lowered. During the month, however, there was practically an equal division of advances and declines in Dun's list of wholesale quotations. Hides, leather and textiles have been prominent by reason of their increasing firmness. Transactions in those commodities have been increasing, except where a paucity of supplies has restricted dealings, and sales of some kinds of cotton goods have exceeded output. On the other hand, business in steel, while recently of a larger volume, has become more highly competitive, with further concessions in prices and a consequent narrowing of profit margins. Yet such a situation does not obscure the fact that potential needs are very large, and the maintenance of a close balance between production and consumption helps to keep fundamental conditions strong. This is a feature which exists in various lines, and nothing has occurred in the first month of the new year to seriously impair the business outlook. Broadly viewed, trade movements have lacked uniformity and in some instances have not equaled expectations, but concrete proof of improvement in different channels has been revealed.

Reports indicate a slackening of the noteworthy activity which the building industry has experienced for several years. In many cities, however, the number of permits issued during 1926 was far in excess of the record for the immediately preceding year. The abatement of operations, where it has appeared, has been most pronounced during the last six months. While no particular department of the industry is conspicuous in the decline, evidence of a reduction in the construction of residences is apparent. For the first time in a number of years, the building of homes seems to have caught up with the demand, in some sections, at least, and from now on, activity is expected to be centered more on industrial and municipal work.

During the last week of February there was an improvement in steel business, with automobile demand picking up and car plants working on a better schedule. There was also a greater inquiry for pig iron, but further price concessions have developed in that quarter, as well as in the steel market. Construction concerns are reported to be operating actively, and fabricators are also on a high basis, although lighter schedules are in force at some centers in the East. In most lines there is an increasing tendency to contract for the future, with the comparatively large number of car orders the outstanding feature.

The improvement in the textile situation has been progressive, and a number of favorable phases have appeared. Production in some divisions has begun to gain again, and distribution in wholesale channels has shown a tendency to expand. Some hesitation has appeared in certain places where unsatisfactory agricultural results have been a factor, but there have been offsetting influences in other sections. In the main, a much better Spring movement of goods is expected.

Items of Interest

The A. S. T. M. During 1926*

The year 1926 was an eventful one for the American Society for Testing Materials. Its technical activities have gone forward with as rapid a pace and have been as productive as at any time in the Society's history. Much of this has been due to its committees for they are the life of the Society. Of these committees there are now 45, a new Committee on Natural Building Stones having been organized during the year. A number have found it necessary to increase their membership in view of the diverse subjects now receiving their attention, the membership of the committees now totalling 2100. An idea of the virility and activity of these committees may be gained from the reports presented at the annual meeting, reports having been received from 36 of the committees.

While the standardization work has not been neglected in any respect, as may be seen from the fact that 54 new standards were submitted as tentative, making the present total of standards and tentative standards 447, greater attention has been paid them at any time heretofore to the promotion of research. Many of the committees have carried on extensive research investigations either in the form of correlative and cooperative tests to settle some feature of its standardization work or as pure investigational work. In addition a wealth of material has been brought out in the technical papers read at the meeting.

It is appreciated that it is not sufficient to merely produce standards or to present results of extensive researches. It is necessary that industry avail itself of this information and benefit by the standardization work by putting it to use. Greater publicity is accordingly being given to the Society's work, through the activities of the Committee on Promotion of Usefulness. This greater publicity is reflected in the increased demand for the Society's standards and other publications.

Corrosion

The accelerated tests in greatest prominence are possibly those dealing with corrosion, since this subject has long held the attention of technicians. Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys has devoted its attention almost exclusively to the standardization of such accelerated tests and a study of the existing tests.

The work on corrosion, however, has not been confined to a study of tests and of the effect of corrosion on various metals, but has reached a point where definite specifications and materials specifically designed for corrosion resistance are being developed. Specifications were presented at the 1926 convention.

Fatigue of Metals

The importance of corrosion as a factor in the fatigue of metals is brought out in two papers presented at the annual meeting, the paper by D. J. McAdam, Jr., entitled "Stress-Strain-Cycle Relationship, and Corrosion-Fatigue of Metals," and the paper by R. R. Moore entitled "Effect of Grooves, Threads, and Corrosion Upon the Fatigue of Metals."

Iron and Steel, General

Two new specifications for commercial bar steels, one covering commercial quality hot-rolled bar steels and the other commercial cold-finished bar steels and cold-finished shafting, have been prepared to replace the present Standard Specifications. Specifications for Cold-Rolled Strip Steel were presented, the preparation of which represents a great deal of work in the harmonizing of ideas among manufacturers and consumers.

Cement and Concrete

One of the outstanding accomplishments of Committee C-1 on Cement during the year was the revision of the Standard Specifications and Tests for Portland Cement resulting in the adoption of new specifications. The principal changes involved are the elimination of the specific gravity requirements and the increase in the tensile strength requirements both at 7 and 28 days. The committee is looking into the possibility of substituting a new test for the present tensile strength test. This would consist in what is known as the fluid cement water mixture which would become the criterion of the concrete-making value of portland cement. Compression tests are made on neat cement mixes with about 40 to 50 per cent of water by weight and poured into molds. This has received the study of the committee during the past few months and further tests of a cooperative nature will be carried out for the purpose of furnishing a basis for possible strength requirements.

Concrete is likewise receiving considerable attention, principally in connection with the problems attending the preparation of specifications for concrete. Committee C-9 on Concrete and Concrete Aggregates is at work on several of the phases involved, such as the formulation of satisfactory specifications for aggregates including a study of the weathering resistance of aggregate materials. Tests are being conducted to show the effect of freezing and thawing on concrete and an endeavor is being made to develop tests to eliminate aggregates that would produce unsound concrete.

A study is also being made on deleterious substances in concrete. This study includes an investigation on the use of dirty stone as coarse aggregate and the effect of sodium silicate on fluid neat cement pastes and on tests of mortars made with washed standard sand.

Coal and Coke

Committee D-5 on Coal and Coke presented in its 1926 report revisions of the methods of tests of standards under its jurisdiction. In addition to the methods heretofore reported upon it is investigating methods of test for agglutinating value of coal, the interpretation of such methods in terms of properties of coal desirable for specific purposes such as coke making, gas production, and its action on grates.

A thorough investigation is being made of methods of collecting representative samples of powdered coal from unit pulverizer systems. A report was presented on standard sizes for anthracite coal and a number of screening tests have been conducted on anthracite as well as experimental work in regard to collection of samples for the screen test.

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*Extracts from a review in the A. S. T. M. Bulletin, January, 1927.

Standard Specification Steam*

Is it Possible to Have Mechanical Carryover of Impurities From Boilers Where the Percentage of Makeup is From Evaporators? There is no doubt that where conditions make their use practical, evaporators naturally go a long way toward keeping down the concentration of impurities in boilers. But they cannot accomplish everything. Evaporators are, in effect, water vapor. There is a mechanical carry-over of water with the steam from evaporators, just as there is from boilers, or in fact from even the finest of laboratory stills. So that, here too, it is only a question of time before the extremely small quantity of impurities carried over from the evaporators into the boiler feed may cause comparatively high concentrations in the boilers. That this is not theory is proved by the fact that at the present time several companies are known to be in search of some method of preventing such carryover from their evaporators.

Often, too, evaporators operate with higher concentration than do the boilers themselves, so that a given percent of mechanical carryover of liquid carries with it more impurities than the same percentage of moisture does from the average boiler, even at unusually high boiler concentrations.

Impossible to Eliminate All Foreign Matter

So that the inevitable conclusion is that it is not possible, even with evaporators, to entirely eliminate all foreign matter from the boiler. And it should be remembered that where evaporators are used the water and steam system is practically a closed system. Except for absolutely unavoidable leaks, and proportionately speaking, extremely small boiler blow-down, there is no chance for the escape of impurities from the system. And because it is a closed system, there are other ways in which impurities are continually entering the system and increasing the boiler concentration.

Then, too, one must not lose sight of the fact that the evaporator make-up is not necessarily the only make-up of water. A plant may have only three or four percent total evaporator make-up, but due to water-gland and condenser tube leakage, another three or four percent may easily enter the system, and this unmeasured make-up is, unfortunately, raw untreated, water, with perhaps a very high percentage of total solids.

And, because the steam and water system is a closed one, one particular minute solid may circulate through the system twenty, or a hundred times before it finally chances to be blown out of the boiler blowdown. That same one particular minute solid may pass through the turbine scores of times, each time with its fellow members acting as an abrasive.

Therefore, while evaporators go a long way toward keeping down boiler concentration, they do not absolutely prevent. It is merely a question of degree and time.

Some Plants Have Solved the Problem

In one of the largest of these plants, 90% is condensate and 10% distilled from evaporators. After a short time they found that they had trouble due to superheater elements burning out.

One of their boilers was then equipped with a steam purifier of the staggered, multiple-baffle, low-velocity type, and it went on the line at about the same time as the three other boilers of the same group, under the same operating conditions.

They have not lost a single element on this boiler's superheater, nor is there evidence of dirt in the superheaters or mud in the upper steam drum. All of the other boilers of this group have lost anywhere from six to eight tubes, and there is always three or four inches of mud in the upper drum. Based on this excellent performance, all of the rest of the boilers at this plant have been similarly equipped. These boilers are exceptionally large ones, and one of them has already been run to more than 500,000 pounds of steam per hour.

At a large central station in Pennsylvania, where conditions are as nearly ideal as it was possible for the best engineering talent of the country could make them, the boiler feed make-up consists of less than three percent, and that distilled water. It was not until they began to lose superheater tubes due to clogging with impurities carried over from the boiler that they realized that it was possible to have mechanical carryover of impurities under their excellent operating conditions.

Many of the larger plants are continually losing superheater elements, and are replacing turbines, the blades of which have been eroded by dust in their steam, without realizing what the dust is and why it is there. Do they also consider the enormous waste of steam that began the moment the blades started to deviate in the silghtest degree from the carefully-calculated contours laid out on the drafting board, and steadily increased until the turbine was retired for reblading? If the curve of inceasing water rate were a straight line, the average is, of course, one-half the total rise, and the total amount of steam wasted is one-half the rise extended over the entire time the turbine was in service. This is an indication of the high cost of dust carryover, even if in extremely small amounts.

It is encouraging, however, to know that this great waste can be entirely prevented by the use of standard specification steam instead of ordinary steam containing boiler water or dry dust.—S. G.

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*Continued from page 27, January, 1927, issue ENGINEERS & ENGINEERING.

The Fallacy of Unnecessary Strength

Excessive and unnecessary strength in the use of mortar in the tremendous building program throughout the country during the past year cost the nation millions of dollars that might have been expended in new and needed structures. This waste and extravagance is influencing the slackening of building operations. It is safe to assume that during 1926 there were at least 8,500,000,000 bricks used. In common bond these bricks require 4,725,000 cubic yards of mortar. A fair average price for the materials in a cubic yard of 1:3 mortar is $9.40 if Portland cement plus 10 per cent of lime is used, $7 with a 1:1:6 lime cement mortar, $7.25 if bricklayers' cement is used, and only about $4.75 if lime is used. It costs as much to mix one kind of mortar as it does another, so that cost of materials makes a fair comparison. There are cases where the higher strength obtained by adding some Portland cement to lime mortar is necessary, but these cases would hardly total 25 per cent. If 75 per cent of these 8,500,000,000 bricks are used for the general run of building, and are laid in lime mortar, the saving follows:

	1:1:6 Lime-cement	Bricklayers' cement	Cement plus 10% lime
Cost of mortar for laying 75 per cent	$24,806,300	$25,692,200	$33,312,300
Cost of 75 per cent in lime	16,832,800	16,832,800	16,832,800
Saving if straight lime mortar is used	7,973,500	8,859,400	16,479,500

The average workman can lay 1400 bricks per 8-hour day in a 12-inch wall (common bond) when he is using lime mortar, but only 1200 when he uses a cement mortar. Using the same figures as before the saving in time required would be 75,890 days if straight lime mortar is used.

If the bricklayers were paid at the rate of $1.50 per hour, their time would be worth $910,680. Also, for every hour of bricklayers' time which is saved there would be one hour of common labor time saved for the men who serve the bricklayers. Consequently, there is the additional saving of 75,890 days of common labor time, which at the rate of $0.90 per hour would amount to $556,400. If lime mortar were used, this saving would be:

Bricklayers' time	$ 910,680
Common labor time	556,400
Materials	16,479,500
Total	$17,946,580

Any building code will permit a loading of at least 90 pounds per square inch on brickwork laid in lime mortar. Most codes permit 100 pounds per square inch and some permit 125 pounds. The recent report of the Department of Commerce Building Code Committee—"Minimum Requirements for Masonry Wall Construction"—states that when allowance is made for eccentricity and concentrated loading, bending, etc., a loading of 135 pounds per square inch is safe. Recent tests on ordinary good clay brick construction, made on sections of 8-inch walls laid up in lime mortar and broken at the Rock Island Arsenal, showed an average 28-day compressive strength of 695 pounds per square inch. Similar results were obtained on wall specimens tested at the Bureau of Standards.

Stream Pollution

A reprint, No. 1063 from the Public Health Service Reports contains:

1. A Review of the Work of the United States Public Health Service in Investigations of Stream Pollution, by W. H. Frost, Surgeon.
2. The Rate of Deoxygenation of Polluted Waters, by Emery J. Theriault, Associate Chemist.
3. The Rate of Atmospheric Reaeration of Sewage-Polluted Streams, by H. W. Streeter, Sanitary Engineer.
4. Quantitative Studies of Bacterial Pollution and Natural Purification in the Ohio and Illinois Rivers, by J. K. Hoskins, Sanitary Engineer.

This pamphlet contains in convenient form the above information of great interest and value to Sanitary Engineers.

Sewage Disposal

Fifty-six municipalities of the Tri-State District (New York, Pennsylvania, New Jersey) have no public sewage facilities whatsoever. Thirty-six have sewers but no disposal plants. Thirteen have disposal plants but no treatment facilities. Twenty-six have disposal plants providing for both separation and treatment.

Almost every stream in the region has been polluted through the use of its waters in lieu of disposal plants. In many instances the existing situation cannot be remedied, either economically or satisfactorily, except through the cooperative effort of two or more communities. Such cooperation has already been brought about largely through the work of the State Board of Health in the Cobbs Creek and Tacony Watersheds, and in the Chester District.

Regional Traffic Control

Delaware County, Pa., is giving an excellent demonstration of the possibilities of Regional cooperation in the widening and paving of Chester Pike. The reinstatement of this turnpike as one of the main thoroughfares connecting Philadelphia with cities to the south, was made possible by the setting aside of individual interests and viewpoints, and the cooperation of the state, county, boroughs, townships, and public service corporation authorities in a joint program. But with the opening of the highway great confusion appeared likely through the varying traffic regulations, signal lights and independent police control of the different authorities. The townships and boroughs along the way, following their original efforts in cooperation, have now united in the employment of a police patrol who have authority along the whole length of the pike, and in the standardization of a signal system. This unification of control might well be followed by other groups in the Philadelphia Region.

Turbine Operating at 1200 Pounds Pressure

The Milwaukee Electric Railway and Light Company is operating a steam turbine-generator which uses steam at a pressure of 1,200 pounds, between three and four times the average pressure and, with one exception, double the pressure in use in any other station. The one exception is the 3,000-kilowatt turbine-generator in the Edgar station of the Edison Electric Illuminating Company of Boston, which also operates at 1,200 pounds pressure. The Milwaukee machine sets a record, however, in that it has a capacity of 7,000 kilowatts, more than twice that of the Boston machine.

The Milwaukee turbine receives steam at a pressure of 1,200 pounds per square inch, superheated to 720 degrees Fahrenheit. It exhausts at 320 pounds pressure, the steam being conducted at this pressure to the station mains serving several 30,000 kilowatt machines where more of its energy is extracted. Final exhaust is at one inch absolute.

A. I. E. E. Standards No. 33, Electrical Measuring Instruments

A new section of the Standards of the American Institute of Electrical Engineers, No. 33, is now available in final approved form. This section was adopted December 10, 1926, and is to become effective April 1, 1927.

These Standards apply to the following kinds of indicating electrical instruments for direct current and alternating current; ammeters, voltmeters, wattmeters, reactive volt ampere meters, frequency meters, power factor, reactive factor, phase angle meters and synchroscopes.

These Standards are not intended to apply to indicating instruments provided with arrangements for curve drawing, contact making, etc. They do not apply to the following kinds of instruments:

(a) Small instruments of types and sizes which are used where low cost is essential; for example, small polarized-vane ammeters used on automobiles, battery-charging outfits, etc.

(b) Instruments constructed for very special requirements.

The various headings of the sections are: Definitions, Rating, Heating, Characteristics, Dielectric Test, Insulation and Construction.

This Standard has been in preparation a long time, and will be greatly used by the industry. Copies may be obtained from the American Institute of Electrical Engineers, 33 West 39th Street, New York, N. Y., at a price of 30c each.

Rating of Heating Boilers

For some time the matter of rating low pressure heating boilers has been in a chaotic condition, unsatisfactory to engineers, architects, manufacturers and contractors throughout the country. The situation was noted by the United States Bureau of Mines and called to the attention of the American Society of Heating & Ventilating Engineers as a most disturbing condition in the industry. The Bureau suggested the appointment of a Committee to study the situation from all angles, in an effort to provide a satisfactory solution of the rating question, particularly as the repeated efforts of manufacturers and others had failed because of competitive conditions and trade jealousies.

H. P. Gant, Chairman of the Society's Committee on Research, appointed a Technical Advisory Committee, no member of which is in any way connected with the trade.

From the results of a survey the Committee will draft a report to be presented at the Society's Annual Meeting in St. Louis, January 26-28.

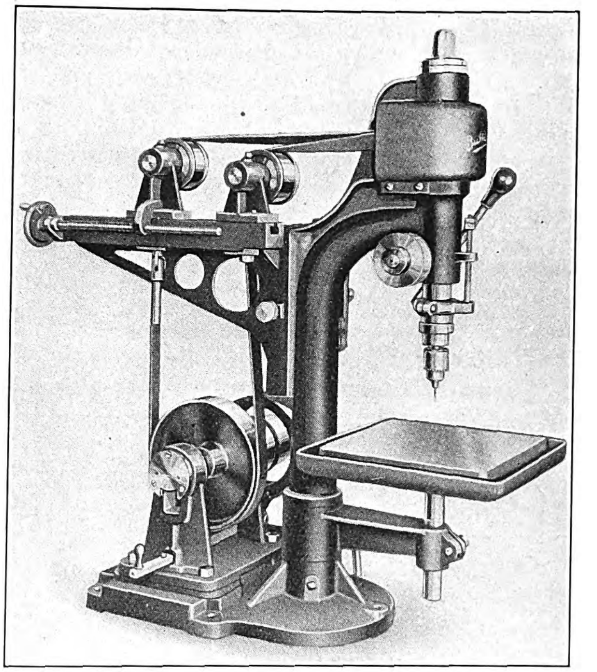
New High Speed Drill

A new 12-inch Hi-Speed Drill has been designed to run at 4 different spindle speeds up to 10,000 R.P.M.

Specifications. Overall height of drill 34"; travel of spindle 3½"; spindle diameter 7/16"; maximum height of spindle to table 6½"; speed of drive pulleys 1800 R.P.M.; number of speeds 4 (10,000, 7,200, 4,800, 3,600); maximum speed recommended 10,000 R.P.M.; drills to center of 12" circle; net weight 215 lbs.

The construction of this new drill is simplified in a way to effect noteworthy economies in production and operation. The design is based on a half century's experience in the production and use of all types of drills from the smallest hand drill to the 25" power drills for heavy production. In fact this one drill represents over two years of experimentation and shop trials before it was released for distribution.

It effects big economies in production not only by higher speed but also by increased accuracy and fewer breakages. It enables the operator to get the maximum cutting efficiency out of his drills by running them at the correct speeds for the different materials and sizes. Change from one speed to any other of the four is quickly made by a lever and quick acting screw. This encourages the operator to change to the efficient speed for the work he is performing.



This Drill is particularly recommended for production work. Automotive industries, instrument makers and similar manufacturers.

In order to make a drill which will stand up under the enormous stresses of 10,000 R.P.M., every part must be of the best material, correctly designed and accurately finished. The Nth degree of precision and perfect balance are indispensable. Ball bearings are used throughout. Equipped with a balanced chuck with capacity from 0 to 5/16".

The drill is also being built for direct motor drive, using a ½ H.P. electric motor. ENGINEERS & ENGINEERING will be pleased to furnish additional information.

The Shipyards Need Work

Pending the enactment of remedial legislation for the upbuilding of the American merchant marine the situation confronting American shipyards has become desperate and temporary work must be provided if the industry is to survive. Both the Navy Department and the Shipping Board have plans under way for the construction of new tonnage recognized as required for the efficient operation of our existing fleets. The shipbuilders ask that steps be taken to realize this work immediately.

A number of shipyards have already closed down and prompt action is necessary to save the remaining ones from a similar fate. The statement is made that the industry is not asking any form of direct aid except new contacts, but these must be immediately forthcoming and the shipyards cannot await the delays incidental to the legislative solution of our merchant marine problem.

The fate of the industry rests with the government and its solution of the shipping problem. The plight of the industry is the inevitable result of the lack of a definite maritime policy on the part of the nation. Prior to the war at least 60 per cent of the volume of work performed by the large shipyards of the United States was for the Navy Department. The war brought an expansion of shipbuilding facilities far in excess of normal demands. Since then Naval disarmament has reduced the construction of warships almost to the vanishing point. Consequently the shipyards must depend for their existence upon the building of mercantile vessels. C. S. K.

The Tangent Method of Analysis for Indicator Cards of Internal Combustion Engines

Indicator diagrams have not been used very extensively for studying the performance of internal combustion engines. One of the drawbacks has been that it is not easy to interpret the record directly in useful terms. An indicator diagram shows the pressure changes taking place in the cylinder in relation to the piston travel but fails to show the heat movement, i. e., where heat is absorbed and where heat is given up by the working fluid. This is an important point in an internal combustion engine where both the production of heat and its conversion into mechanical work are performed within the cylinder.

It has been customary to use the exponents "n" to derive information regarding the heat flow. Several methods have been proposed to evaluate the "exponents" from the indicator diagrams but all of them are more or less cumbersome and have not become popular.

To overcome this difficulty a new method of analyzing indicator diagrams has been developed. The tangent method of analysis is simple in execution, is sufficiently accurate and has been of distinct assistance in testing internal combustion engines.

—Penna. State College Bulletin No. 35.

Sheffler-Gross Co. have been appointed the Philadelphia representatives for the L. J. Wing Mfg Co. of New York City, manufacturers of a high grade line of Forced Draft Blowers, (Motor Driven and Turbine Driven) and Unit Heaters of the suspended type. This concern has been doing business for over twenty-five years and maintain an up to date factory at Newark, N. J. Their staff of engineers are in a position to co-operate with Sheffler-Gross Co. so that the best service can be given to their clients in this district.

H. P. Gant, of Philadelphia, on January 1st, became affiliated with the York Heating and Ventilating Corporation, as Vice President, with headquarters at 1502 Locust Street, Philadelphia.

This announcement will arouse wide interest, as Mr. Gant is one of the best known heating and ventilating engineers in the country.

In 1923, Mr. Gant was President of the American Society of Heating Ventilating Engineers, and in 1926, National Chairman of their Research Committee.

This change will reunite two old friends and former partners, Thornton Lewis and H. P. Gant, who were in partnership for about ten years, but have been working independently for the past few years.

NEW BOOKS

BOOK REVIEWS

Orders for any books, domestic or foreign, will be filled promptly by shipment direct from publisher. We receive orders for all classes of books—**fiction, biographical, technical, historical, etc.** We solicit your business.

ENGINEERS AND ENGINEERING,
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Compound Interest and Annuity Tables—By Frederick C. Kent, Assoc. Prof. Mathematics, Oregon State College, and Maude E. Kent. 214 pages. $4.00.

This book of tables gives compound interest and annuity values for 36 rates of interest and values in part for 15 additional rates, or 51 rates in all—for 1-100, 1-200, 1-300 interest periods—all expressed accurately to ten decimal places.

It gives conversion factors to ten decimal places for 36 rates of interest and the compound amount of 1 values to fifteen places for fractional rates, ¼ of 1 per cent to 1 per cent inclusive. Quotient tables and logarithms are also included.

Practical Radio (Including the Testing of Radio Receiving Sets)—By James A. Moyer and John F. Wostrel. 270 pages, 5x8, illustrated. $1.75.

The book presents the fundamental principles of radio so simply and clearly that any person of average training will be able to read, understand and apply them. Both the inexperienced amateur and the technically trained specialist will find the book valuable. In Chapter XI there are accurate working drawings as actually used in radio shops together with complete lists of materials required for constructing eight typical receiving sets.

Reinforced Concrete Design—By Hale Sutherland, A. B., S. B., Associate Professor of Structural Engineering, Massachusetts Institute of Technology, Mem. A. S. C. E., and Walter W. Clifford, S. B., Consulting Engineer, Boston, and Mem. A. S. C. E. 413 pages 6x9. $4.00.

This new book presents the fundamentals of reinforced concrete design as simply and completely as possible. The method of the transformed section is used for the development of the theory as it is believed to be by far the clearest and most logical approach. It has the great advantage that instead of leaving the student with a mass of formulas which are often difficult to visualize, it impresses on his mind the basic concepts of the subject and frees him from dependence on texts and equations. Enough is included about the modern theories of concrete, formwork, drawing and detailing to give a good background of knowledge in matters where real proficiency can come only with experience.

The Romance of Comets—By Mary Proctor, F. R. A. S., F. R. Met. S. 210 pages. $2.50.

Who has not wondered about the comets? Whenever these strange visitors from the star-depths have appeared, they have sent all mankind hurrying to its windows or to its housetops to observe, to wonder, and often to fear. Until recently the phenomena have been surrounded by mystery and their origin understood only by scholars.

"To hunt for a comet in the ocean of space is as fascinating a hobby as angling for a wily fish." Her method of presentation transforms this branch of astronomy from an abstruse mathematical science into an absorbing study within the comprehension of any intelligent reader.

Evenings With The Stars—By Mary Proctor, F. R. A. S., F. R. Met. S. 219 pages. $2.50.

This book exactly fills the needs of those who have no technical knowledge of astronomy but who realize the fascination of "star-gazing" and would like to be able to do it intelligently. Its method of presentation is of unique and special value.

The position of each constellation is described, with the aid of very graphic charts. And the constellations are also considered from the standpoint of history and mythology, with fascinating sidelights on the wealth of legend surrounding each.

The author is not only the daughter of one of England's greatest astronomers, but is herself a distinguished scientist of international reputation.

A Selective Bibliography of the Literature of Lubrication—By Nathan Van Patten, Librarian of Queen's University, and Grace S. Lewis, Librarian, Dominion Bureau of Statistics. 170 pages. 6x9. $5.00.

This bibliography has been in preparation for two years. A careful effort has been made to give references to all important articles relating to the chemistry, testing and use of lubricants, appearing in the technical journals of the world or in book form since 1900.

The work contains 2,388 references and a comprehensive index of subjects. It is now ready for immediate delivery. On account of the cost of publication only a limited edition has been printed.

Bibliography of the Corrosion of Metals and Its Prevention—By Nathan V. Van Patten, Librarian of Queen's University. 186 pages. 6x9. $5.00.

This is an annotated bibliography of the literature of the corrosion of metals (ferrous and non-ferrous) and its prevention. Its scope includes the theory of corrosion, electrolysis, and the prevention of corrosion by alloying, metal-coating, passivity, painting, etc. The bibliography contains over two thousand references, together with a complete index by subjects. Two editions have been printed and only a few copies remain for sale.

Who's Who in America—Edited by Albert N. Marquis. For 1926-1927. The Standard Biographical Reference Book of the United States. 2,300 pages. $8.50.

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ASSISTANT STRUCTURAL ENGINEER, to make computations and designs for foundations, floor constructions, columns, etc. To check drawings submitted by contractors. Vacancy is in the Supervising Architect's office, Washington, D. C. Salary $2400, with promotion after 6 mos. Application forms may be had from U. S. Civil Service Com., Wash., D. C.

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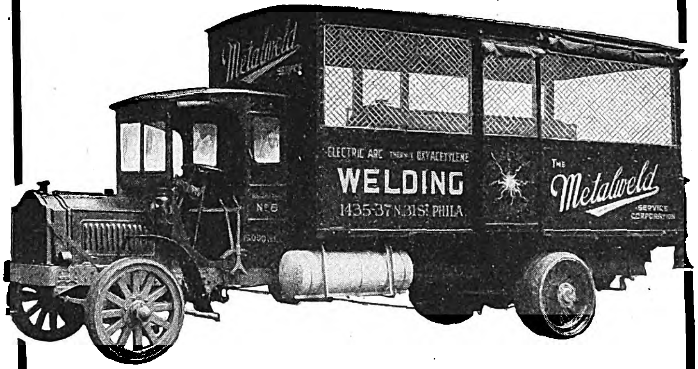
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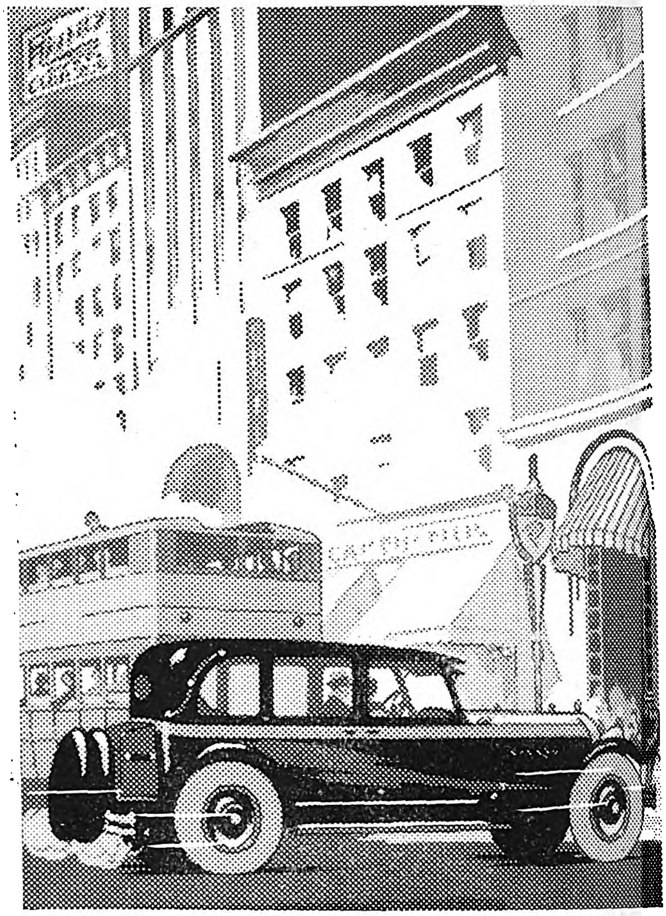

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City Traffic Problems*

By WILLIAM B. POWELL
Consulting Engineer, Buffalo, N. Y.

THE traffic problem is one that we are all in daily contact with. Practically every one drives an automobile today; if they don't at least they have to dodge one when they walk to their place of business, so that we are all in very active contact with this very troublesome problem.

The problem is essentially one of engineering, but it has some collateral relationships which make it a difficult one to handle. It is a political problem quite as much as an engineering problem, and the consequence is the engineer up to the present time, as far as I can see, has not functioned in it nearly as much as he should.

A few years ago when this traffic problem first came upon us rather unawares, with the tremendous growth of the automobile, the first man that came in contact with it, of course, was the man on the street, who was charged with keeping the street in order. That was the policeman, and the police point of view is very different from the engineering point of view. The policeman met the problem as it came to him and did the best he could with it. He was not qualified, either by education or experience, to plan the essentially proper moves to solve the problem, but he did what he could, and was very rapidly overwhelmed. In most cases the natural result was, when they failed with a few men they put on more, and more, until we found in most cities, the precincts were drained of men to handle our traffic problem to such an extent that we were laying ourselves open to appalling burglaries and other troubles in the outlying districts. In Buffalo, we have no more police on our force today than we had ten or fifteen years ago, and at the same time we have had to draw something like 150 men from the force to handle traffic in the downtown area, and quite a number more to handle school crossings throughout the city, during the day. All of them are withdrawn from the precincts and largely from the night shift. For instance, in one of our precincts which has seventeen posts, we formerly had seventeen men patroling, while now we are lucky if we get five at night. That is just an illustration of the effect of the traffic problem on general policing conditions.

As I said, the problem is an engineering problem, and the engineer has not gone into it as he should; but there is a very good reason. The engineer is not a politician by nature. His habit of mind is entirely different from the political habit of mind, and in order to do much with the problem he has to get into politics or at least he has to play the game according to political rules. So what we find is this, that where the engineer has come into the problem he has generally been brought in as a consultant, has been asked to make a survey and report, which he has done in good engineering style, has turned in a report of great volume, perhaps in a printed pamphlet, which being voluminous and requiring a large expenditure to carry out its recommendations, has been promptly put in a pigeon-hole, and we have gone right on just as we were. Now the engineer is really, in a case of that sort, a city planner; and I have no criticism to make of my brother city planners whatever. They are doing a fine job, but their aim is towards ten or fifteen or twenty-five years in the future, and what the police people need is help for the immediate present, tomorrow, today, and that is the part of the problem that the engineer so far has not generally tackled in a successful manner. There are a few cities—I know of three or four—where engineers have been brought into the picture in one way or another. Pittsburgh has a traffic engineer who is attached to the Mayor's Department. Detroit has one also. Both of them are young men, trained in the city planning field originally, but very active in the more immediate field of the things that have to be done from day to day. In Buffalo, I am acting as consulting engineer to the Chief of Police under authority of the Mayor, and in Washington they have a commission which has a traffic engineer on it as an assistant. In those cities, we are beginning to bring the engineering viewpoint in contact with the daily problem, and we have made some little degree of progress. There are many other cities where, so far as I know, no progress at all has been made in that direction.

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*Address before the Engineers' Club, January 11, 1927.

It may be presumptuous for me to come from a small city like Buffalo to tell you how to handle the problem of traffic in a big city like Philadelphia. Your problem is not exactly the same as ours by any manner of means because our city is still to a certain extent in swaddling clothes. We have not yet outgrown the habit of driving from our homes to our offices in our automobiles, leaving the automobile somewhere near the office, and perhaps using it once or twice during the day and driving home in it at night. The larger the city the less you can do that sort of thing, unless in the meantime you have developed particular facilities for that purpose. On the other hand, perhaps I can tell you something about traffic control in the smaller city from the very fact that it is smaller and therefore has had more opportunity to experiment.

In Buffalo we have had a very credulous council, in control for a number of years, and when traffic signalling first came on the map they bought every signal that was offered, regardless of its merit or anything else. They bought anywhere from one to ten, depending upon circumstances, which I won't go into, but at any rate we got at least one of every kind that was offered. That gave us a wide range of experience, and I am frank to say that on the basis of that experience we think now that our signalling is as nearly perfect as we can get it under the present state of the art. We have come to the definite conclusion that we do not want obstructive signals in our streets anywhere. We do want them suspended overhead where they can be easily seen, which means in the center of street intersections. We do not want an amber light to warn the standing automobile to jump out in the way of one that is just passing on the end of the green turn, so we only use red and green. We overlap the reds for a period of five to fifteen seconds, depending on circumstances to clear the corner. We find our motorists even then are jumping the signals, although not nearly to the extent that they did when the amber lights were used. We are shielding our signals so the red light cannot be seen by the driver waiting on the cross street. We have taken all of our blinkers out of the center of the street intersections and put them on the end of dead streets, or on curves, or dangerous points, in order to get them out of the way.

I do not think we have gotten anywhere near the end of signalling. Right now, signalling works pretty well when you have two thoroughfares heavily loaded with traffic. It sorts the traffic and gets it across the intersection safely in a very good way, but the great objection to it is that when you approach one of those signals in the middle of the night and there is no traffic in sight in any direction, it is a hardship just to be a good law observer, to sit there and wait for an interval of perhaps forty-five seconds, or a minute, for the signal to change, and, if you are not a good law observer then, and go across on your judgment, you naturally would be inclined to go across on your judgment at any other time of the day. Hence, at least three or four efforts are being made at the present time to develop such a signalling system that when there is light traffic on the streets, the signal will change at the approach of each car in either direction, and only when there is a dense enough traffic to make it worth while will the automatic timing system come into effect. That is easily possible from the electrical side, but difficult from the physical side, due to the fact that some means of connection is required between the automobile and the pavement, and when you have to deal with weather conditions such as we have in Buffalo, which means for five or six months in the year a snow, and a thaw and a freeze, you have a real physical problem to deal with that is difficult. Our street railway companies find that to be the case in keeping their switches clear, and a system of this sort such as I have indicated, would probably be equally or perhaps more difficult. I hope to see a development of that sort come from some Southern or Western city, such as Los Angeles, or Miami, or some place where they have no bad weather conditions. That will go a long way toward developing the signal toward ultimate perfection.

It is a curious fact that if you make a spot map of the accidents, or the fatalities, that occur in a city, you will find that the fatalities particularly, and many of the accidents as well, do not occur at any point where you can control them. Last year we killed 116 people in Buffalo, and of those 116 people, upward of 80 were killed at points that could not possibly be put under police control. I mean by that, in residential streets, in the middle of blocks, places where nobody would think of trying to regulate the traffic. That means that something more than signalling, something more than police control, has to be accomplished. That something is the education of the public. That is not an engineering problem; that is a publicity problem, and I am not prepared to speak on it further than to point out the tremendous necessity for it. Again, when you make a spot map of accidents or fatalities, an apparently heavy accident occurence is shown on main thoroughfares, but if against that, the traffic flow on the same street is plotted, the ratio between accidents and flow is lower on the busy streets than it is on the remote streets that are not busy. I haven't seen that worked out anywhere in a diagramatic form, but I shall try it. I have studied certain particular streets enough to know that it is a fact. The same thing is true with regard to signals. Signal corners relatively do not produce as many accidents as unsignalled corners. A signal is not a device for moving traffic rapidly; it is for safety, primarily,—you always get that complaint, that a signal slows up traffic. Of course it does. The only way to meet that is to provide a signal system such as they have on 16th Street in Washington, where signals are timed to meet the movement of traffic in a given direction at about its proper average rate, so that the signals change to meet the traffic, permitting it to go through without interruption. That is being done in a few cases—Chicago is the outstanding illustration today, for they have been using that system in the downtown area for a year with a considerable degree of success.

There are a lot of other aspects to the problem besides signalling, and the flow of traffic. The thing that impedes the flow of traffic more than anything else is parking. The business man comes day after day, and says, "This parking situation is terrible. The all day parker is the one that makes all the trouble." Well, maybe that is so; maybe it isn't. I don't believe it myself. I do not believe it for as a matter of fact in most cities today there are very few all day parkers. I don't believe it, more particularly, because we could not possibly accommodate with parking space enough people whose aggregate trade would pay even the ground rent of the stores. Counts which have been made in some cities show about 80 per cent of the patrons of a retail store arrive on foot and not by automobile. But it is hard to make the storekeeper believe that. The attitude of the average merchant is against a change, no matter what it may be. You can meet that to some extent by diplomacy, as we have done in one or two instances. For instance, a year ago we put through a regulation on our main retail street that there would be no parking, or standing vehicles, during the rush hour at night, 4:30 to 6. Anticipating a complaint from the retail men we took a count before the rule went into effect and noted how many automobiles were standing at each individual store during those hours, how many people got off and went in, and how many came out of the stores, got into the autos and went away. After the rule went into effect, the Secretary of the Retail Merchants' Association, on that street, came to police headquarters, to one of our Traffic Board meetings, prepared to make a tremendous objection. He said, "Why, my God, you've killed our business. There is no one stopping and coming into our stores between 4:30 and 6 any more." I said, "Do you know how many were doing it before the rule went into effect?" He had no idea. "Well," I said, "have you got figures with you as to what is happening now?" He had them. I said, "All right. I've got mine, too. Let's put them together." I lined my figures alongside his, and I had fewer calling and going away than he had. In other words, my records before the thing went into effect just by accident happened to be a little bit lower than his. It took the wind out of his sales to such a degree that he did not go into the meeting at all; he turned around and went home.

Now, about parking. The average business man says, "We've got to have some parking, but let's have limited parking. Let's limit it to an hour or to thirty minutes, or perhaps to fifteen minutes, in congested areas, and then we can get all the people in and out who want to do business." Well, can you? Just to meet that situation, not long ago I made a survey of a particular block in our city, which was a typical block, a fair average of any city. On the circumference of that one block 52 autos could park, after making allowance for hydrants, safety zone limits and loading zones. Then, we determined the time on the average that an officer would take to put a tag on a car, and found that the average tagging time per car was two minutes. Supposing that the officer had to tag every car in the block, it would take him 104 minutes to go around the block, so you can see we could not even enforce an hour parking limit on that block. It so happened that they wanted a fifteen minute parking limit. Granting a fifteen minute parking limit, and that he only had to tag a quarter of the cars, he is still out of luck by quite a lot. But that isn't the worst of it. We have forty blocks in our congested area where they want time limits enforced. That would take forty policemen but we have to work them in two shifts, so that means eighty, and we've got—*two;* all that are available. Now, I ask you, what is the chance of a police department enforcing time limit rules even if you establish them? The real fact is, we put up the signs and then trust to the Lord that the people generally will observe them, or at least be afraid somebody is around spotting them, and so live up to them with some degree of care. But we are rapidly approaching the point where we will not allow any parking on our congested streets. We will limit them entirely to loading and unloading of either passengers or merchandise. That is an enforcible rule. A mounted officer can control at least four blocks of an ordinary street, where he has a no-parking restriction to enforce, but a footman can not enforce a single block on time limits. The day is rapidly coming too when most enterprises, mercantile, amusement, or what not, that involve the drawing together of large masses of people, many of whom want to come in their own machines, will have to necessarily provide off-street parking space to accommodate those people. We are getting to that in Buffalo right now. Some of our retail stores either have garages of their own to which they drive the cars of their customers with their own men, subject to call, to bring them back when wanted, or they have working arrangements with nearby garages by which they absorb the parking charges. Further, we are now heading towards double decking one of our markets, near the business area, with the idea of taking the marketing cars off the street during the daytime and the amusement cars off during the night. That is a real answer to the problem as far as parking is concerned.

Keeping the Atmosphere Clean

When an industrial community realizes that keeping the air clean is a project of similar magnitude to keeping streets clean, providing clean water, removing city waste, or guarding the moral atmosphere, then there may be hope of success in smoke abatement, states O. P. Hood, chief mechanical engineer, Bureau of Mines. "We usually think of the project in too small terms. It is thought of as is the dog catcher or the boiler inspector—a matter of a man or two, a job or two, and a small appropriation of variable and uncertain amount, to be abolished in a fit of economy and re-established under pressure of a vigorous minority.

"Even so, it is surprising how much is obtained for the effort; but the community is rarely satisfied, for the job is bigger than it was conceived to be. Continuous, never-ceasing effort is required to clean up a smoky city. A few months of relaxation and some years of effort are canceled.

"It is useless to look for a spectacular cure. Success comes only after long-continued, highly skillful effort. When a new plant goes in and it proves to be a smoker, remedying the condition is difficult. The community will probably have to stand smoke for a long time while the owner spends money temporizing with weak expedients, finally arriving at the conclusion that 'it can not be done.' The remedy is to provide such engineering oversight of new installations as to insure a non-smoking plant to begin with. This can be done. It may mean changes in building plans, a larger investment, a greater responsibility of management, a more intelligent operation, but these things are the price of clean air. The higher grade of installation usually pays well by reducing running expenses. It is of little use to complain of smoky stacks and allow new ones to be added daily. It is not often that smokelessness is one of the main objectives in an installation. Capacity, convenience, efficiency, and low cost come first, with a weak but laudable hope that smokelessness can be had also at no increase in cost. This order must be reversed in the public mind if we are to have clean air. Smokelessness must be a first requirement. These simple illustrations indicate that successful smoke abatement is a problem requiring high technical ability, the administration of a difficult human problem, a change in attitude of a community, willingness to wait for results, and readiness to pay for continuous, long-time effort free from political control. So far we have not found this combination, so that results are incomplete.

"There is a great waste of ineffective effort in smoke-abatement agitation that gets nowhere because of a lack of vision as to the kind of job it is and an unwillingness to pay the price. Engineers believe that it can be done, and at a price not out of proportion to its worth."

Smokeless Coal

The term "smokeless coal" is a challenge to the combustion engineer, stated O. P. Hood, chief mechanical engineer of the Bureau of Mines, in addressing the recent conference on bituminous coal at Pittsburgh, Pa. None of his art is needed to make anthracite and coke burn smokelessly, but as increasing amounts of volatile matter are associated in the fuel, more and more demands are made upon his skill in furnace design, in adaptation to service, and to care in operation to keep within absolute or even practical smokeless limits. Illustrations can be found of smokeless performance of every fuel, so that the statement can be made "that it can be done." That it is not done simply indicates that it is not wanted badly enough to pay the price. Most engineering is a compromise among conflicting requirements. Smokeless operation usually requires the cooperation of several interests, sometimes management of a high order, and often a degree of care and attention difficult to buy. Financial and operating limitations are many. All of these elements enter into practicability of attaining smokeless operation, and obviously each case must be considered by itself.

The Plastic Behavior of Metal in Drawing

Mr. C. L. Eksergian has recently contributed an interesting paper on this subject. Metal drawing, unlike other classes of engineering work, has proceeded mostly as an art rather than a science. The empirical method has of necessity been the basis of advancement, due to the limited knowledge of the attending phenomena.

The purpose of this paper is to foster the development of analysis to drawing as an aid to subsequent development. Toward this end no attempt has been made to set forth any concrete analysis, since the subject is regarded as too complex for such a discussion at present. However, as a preliminary step in this direction, an attempt is made to outline a manner of attack by which a proper conception of the phenomena may be realized. For the present a general discussion is made of the manner of working the metal with reference to its state and behavior in comparison with that found in drawing. A survey of the conditions observed in the forming of a stamping is also made along with a report of certain experimental investigations which were conducted by the author.

Water Wastes and Results of 100% Metering*

By A. E. WALDEN, Chief Engineer,
Baltimore County-Metropolitan District, Maryland

A PAPER of this kind must of necessity be somewhat hypothetical, but should be and is sufficiently correct for the purpose in hand. It would be prohibitive to go into the detailed cost of the many and various items entering into such a project, but comparisons are made in such a manner as will indicate proportional differences in costs of construction and to the consumer where flat rate or metered system of charging for service are in force. While this paper applies more particularly to Baltimore City and its vicinity, the appertaining data with which the writer is familiar, the comparisons are applicable to any large city.

The Nature of Water Waste

The causes of waste are many and may be briefly set forth as follows:

Failure to turn off spigots when using water.

Failure to turn off hose when washing sidewalks, unnecessary sprinkling of lawns and sidewalks, leaky fixtures, and the worst offenders are toilets.

Spigots allowed to run to prevent freezing.

Deferring maintenance of fixtures on account of expense.

Garages now on a flat rate that are supposed to be metered.

The use of a flat rate system of charges that provides an unlimited supply of water irrespective of requirements or amount of waste.

Unauthorized use of non-automatic cellar drainers.

Unauthorized use of water for purposes other than fire protection systems.

Hydraulic elevators, water from which is allowed to flow to sewer and not reused.

Street flushing and flushing of sewers.

Unauthorized use of fire hydrants for steam roller and so forth.

Leaky mains and services.

All of these causes can be controlled automatically by metering and such metering will not add to the burden of cost, but will reduce the cost and increase the quantity of water available.

Leaky fixtures not only add to the cost of water to a given premises, but are objectionable due to the noise, and this is particularly true of toilets; there is an opportunity to reduce water waste by installing toilets that will flush properly with about three gallons of water instead of eight gallons as in many cases.

Sprinkling of lawns, particularly in the morning or through the day, is not only wasteful, but does not produce the results, as grass will be killed by the water evaporating under the hot sun, it will also be drowned out if sprinkled too much or long at night, the best time being just about sundown, using only sufficient water to equal a light rain or dew.

Methods of economical use for each one of the causes of waste enumerated above could be outlined that would allow sufficient water for any purpose except waste.

Proof of Waste and Its Amount

There is no trouble to prove, even to the most casual observer, there is waste where a flat rate system of charges are in effect, and further proof is available from statistics of cities where a change has been made from a flat rate to a metered system with a reduction of 40 to 50 per cent in the quantity of water pumped as compared with the amount formerly pumped under the flat rate system.

Meters are necessary to get a measure of the waste and its location, and they automatically assure the removal of the cause in most cases. Pitometer surveys are made by inserting tubes in a main and measuring the velocity head of water on a recording or photographic chart. This record indicates the quantity at any period of time, and even a reversal of flow. By dividing and sectionalizing a given district the quantity of water supplied that district can be ascertained, but such a record does not indicate whether the use is legitimate or waste.

Where a flat rate system of charges is in effect, the cost of operating, making inspections, pitometer tests, waste surveys and so forth, if done systematically, will more than offset the cost of meters.

Attempts to determine waste by inspection and pitometer test are effective only in small part in reducing the waste. The minute the inspectors leave, or the pitometer survey ceases, the way is clear for waste to begin. It may go on for months or years until another survey is made. But METERS are on the JOB all the time; they are the water department's POLICEMEN. They measure all uses of water, except from the fire hydrants.

A pitometer survey is only partially effective, unless used in conjunction with meters, because such a survey may extend over a period of weeks in one section. Information as to the time of the greatest flow, reversal of flow, minimum flow, will be disclosed together with the quantities, but you cannot tell what this flow is due to, or whether it is entirely due to consumption, or combined consumption and leakage, even if the aquaphone is used at the same time, or if the flow is due to waste or legitimate use, on a flat rate system.

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*Address before the Engineers Club, December 21, 1926.

However, with a completely metered system, a fairly accurate record can be obtained by cutting off, or sectionalizing, any block recording the flow by the pitometer and checking against the reading of the meters in the block.

Proof of the waste is obtained by inspection, observation, and comparison of water pumped by other cities that are wholly or partially metered.

No public utility would be considered as on a sound operating basis if its unaccounted-for product exceeded 10 per cent of its total product, yet the majority of the water departments, and even the privately operated companies, will show unaccounted water equalling or exceeding 40 per cent of the total pumpage. This is particularly true where a flat rate system of charges is in force.

In a gas system supplying manufactured gas, as analogous to the water system, if there is a difference of more than 7 per cent between the station meter registration and the sum of the registration of the consumers' meters, every effort is made to locate losses and put a stop to them.

It is general practice with nearly every water system to install meters costing hundreds of dollars on the force mains. With a flat rate system of charges the only indication these meters give to the operator is the output and the number of gallons pumped per pound of coal.

With service meters the waste can be regulated and checked.

Experience in Waste Elimination

Wherever the water system is metered, either partially or wholly, there has been a marked reduction in consumption and apparently without any reduction in the legitimate use of water.

The per capita consumption in the northern and western sections of Baltimore City and Baltimore County Metropolitan District, 100 per cent metered, is from 40 to 50 gallons daily, and in Catonsville, in the Metropolitan District particularly, before 100 per cent metering, it was 100 gallons per capita daily.

In the Highlandtown section metered less than 20 per cent (and there is a preponderance of industry over domestic use), the per capita consumption is about 140 gallons per day.

The daily per capita consumption in Baltimore City varies from 140 to 170 and the possibilities for a reduction are indicated by the following data from other cities:

CLEVELAND—Professor Bemis stated in 1911 that the reduction in water consumed in Cleveland from 165 to 90 gallons per day per capita, was effected though not wholly through universal metering, and that of the 90 gallons per day per capita, 48 gallons covered business use, and 42 gallons covered all domestic, public, leaks, and unregistering of the meters.

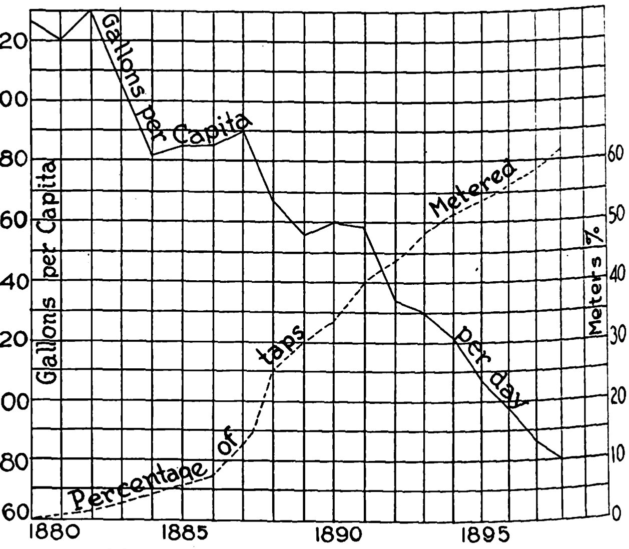
Professor Bemis further stated that with universal metering and proper attention to other forms of waste detection the per capita daily consumption for other than business purposes could be kept below 50 gallons, and that only under very exceptional circumstances was there any justification for a consumption of over 60 gallons to cover slip, domestic purposes and unaccounted for water. Further, that with a well built system of mains, a high grade of meters, and proper attention, all uses of water, save for business purposes, could be kept between 30 and 60 gallons per day per capita.

NEW YORK—Freeman reported for New York in 1899 that the water consumption daily per capita over certain years at Fall River, Mass., was 14.6 gallons; Woonsocket, R. I., 14.1 gallons; Worcester, Mass., 16.3 gallons.

In 1919, Fall River, Mass., the daily per capita consumption was 46 for all purposes.

MASSACHUSETTS METROPOLITAN WATER DISTRICT—In Massachusetts the legislature in 1907 passed a bill ordering the metering within a certain period of years of all service in the metropolitan district.

This is an indication of the trend on matters of such vital interest in conserving not only our natural resources, but reducing, through certain means, the cost of a given commodity to our citizens.

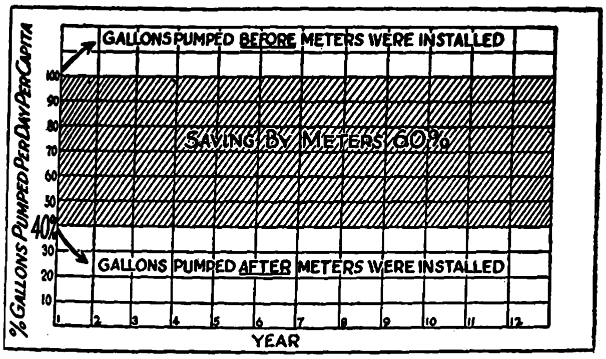


MILWAUKEE'S EXPERIENCE WITH METERS

MILWAUKEE, WIS., in 1898, with about 60 per cent of the total services metered, reduced the daily per capita consumption from about 300 to 80 gallons as shown by curve and while the consumption per capita daily increased in 1921 to 116, 100 of the largest consumers pay for 59 per cent of the metered water. While the use of meters cut down the per capita consumption of water, the experience of other cities indicates that people ARE NOT CURTAILED in their legitimate use of water, but have more water for such use.

LOS ANGELES, CALIF.—Metering has reduced the daily per capita consumption from 300 to an average of 120 gallons, but on account of wide, deep lawns and much shrubbery, it is probable that the water consumption is much greater than would otherwise be the case.

ATLANTA, GA.—Metering reduced the total water pumped by 60 per cent, or from 200 gallons to 80 gallons daily per capita.



RESULTS OF METERING THE SYSTEM AT ATLANTA, GA.

Costs Under Flat Rate and Metered Systems

It is generally considered that 25 to 30 gallons daily per capita, and in some cities, even 15 to 20 gallons per day, are sufficient for the health and cleanliness of the community, and in fact, many fully metered systems have a consumption not exceeding 40 to 50 gallons. Where flat rates are in effect, the water consumption varies from 150 gallons to 200 gallons per day per capita.

Let us assume that a 12-inch main is required to serve a population requiring 10,000 services and, in fact, ordinarily this is ample on the basis of 40 to 50 gallons per capita daily. This main will cost about $20,000.00 a mile. A consumption of 200 gallons per capita daily, and 10,000 services will require a main about 20 inches in diameter, costing $40,000.00 per mile as of this date. Hence, the distribution system for the flat rate is twice as costly.

Next consider the storage reservoir. It is assumed that a reservoir, having a capacity of 10 million gallons will permit of sufficient storage to care for the driest period of the year with a consumption of 50 gallons daily per capita. Statistics show that the cost of such reservoirs vary from 5 to 10 thousand dollars per million gallons or, for 50 gallons daily per capita, a cost of $50,000.00. A reservoir supplying the service on the flat rate system of 200 per capita would require a capacity of 40 million gallons for a similar period and cost $200,000.00.

The citizens must pay the interest, sinking fund, and depreciation on a system many times greater than the one touched on here. In Baltimore the investment in round figures is 30 million dollars, book value, or about $43.00 per capita, this figure varying, of course, from year to year. Taking interest at 4½ per cent, sinking fund 2 per cent, depreciation for the whole system at 2½ per cent, we have an annual charge of 9 per cent on 30 million dollars, or $2,700,000 a year. For the operating expenses we will assume that 110 million gallons daily are required, or 40,150 million gallons per year, and that the operation, purification and distribution cost will equal, or exceed, $25.00 per million gallons. (The average cost in 28 cities has been $80.00). At $25.00 per million the yearly operating cost is $1,003,750.00. We will assume that the system as laid out and with the 15 million dollars expenditure under the present water loan, that there will be sufficient capacity, at 200 gallons daily per capita, for the next ten years, but after that (and there is some question about the capacity being sufficient to even supply the population over that period) there will be additional water storage required necessitating loans for that purpose with all other added expenses.

The question immediately arises as to where to obtain this additional water, land for storage and so forth, and what will be its cost. In the meantime, further deforestation is taking place, decreasing the ability of the area to build up the ground water level, and you cannot obtain the same ground water storage neither can you expect the present run off be maintained for the next ten years, for both the watershed area and the ground water storage are decreasing and the demand increasing, storage basins are filling up due to erosion and silting and in some way the water supply must be conserved.

These conditions are particularly true of Baltimore and its vicinity at this time, preliminary construction work being already under way for increasing the storage with plans under consideration for utilizing the Susquehanna River at the new Conowingo Dam at sometime in the future.

This immediately brings up the question of the disposal of the sewage, the quantity of which follows very closely the water supply for domestic purposes, or about 100 to 150 gallons per day per capita, on the basis of 200 gallons supplied; this, as you will easily see, means more money invested in the sewage disposal plant; an additional burden on the tax rate.

Let us compare the figures:

DISTRIBUTION SYSTEM

Customers 50,000 Services 10,000
Metered System *Flat Rate System*
50 gal. per day per capita . 200 gal. per day per capita
12 inch pipe............ 20 inch pipe
Cost per mile $20,000.00 . . $40,000.00 or twice as great
Excess investment in pipe . . $20,000.00 per mile

Interest, sinking fund and depreciation on excess cost @ 9%............ 1,800.00 per mile

STORAGE SYSTEM

	Metered System	*Flat Rate System*
Cost of storage system.......	$ 50,000.00	$200,000.00
Excess investment		150,000.00
Interest, sinking fund and depreciation on excess cost @ 9%		13,500.00

PUMPING PLANT

Gallons per day per capita....	50	200
Cost of pumping plant*......	$ 44,000.00	$180,000.00
Excess investment in Flat Rate System		136,000.00
Excess annual charges, interest, sinking fund and depreciation at 10%.........		13,600.00
Cost of pumping per million gallons**	10.00	8.00
Pumping cost per year.........	9,125.00	29,250.00
Excess yearly pumping cost Flat Rate System..........		20,125.00
Excess yearly cost pumping, Flat Rate System.........		$33,725.00

PURIFICATION SYSTEM

Cost of Purification System..	$ 50,000.00	$200,000.00
Excess investment Flat Rate System		150,000.00
Excess interest, sinking fund and depreciation at 9%.....		13,500.00
Yearly operation cost at $12.00 per million gallons	10,950.00	43,800.00
Excess yearly operation cost		32,850.00
Excess yearly cost, purification, Flat Rate System.....		$ 46,350.00

DISTRIBUTION SYSTEM

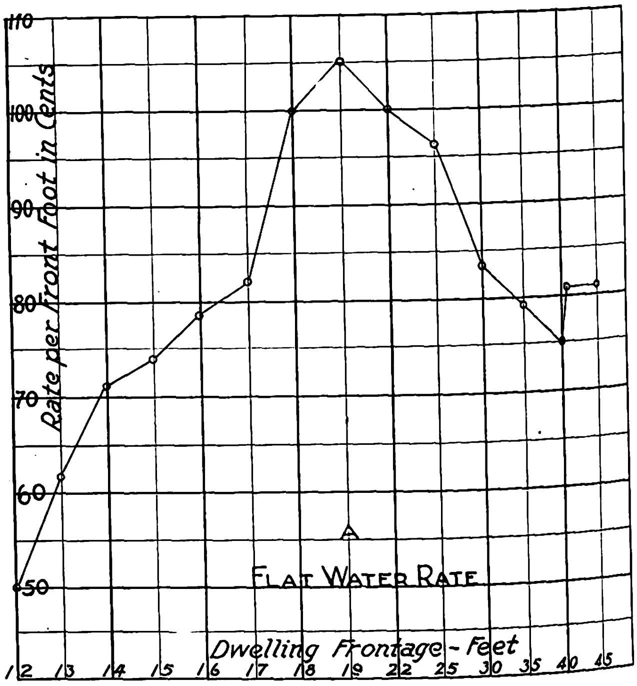
Cost distribution mains (50 miles)	$1,000,000.00	$2,000,000.00
Excess investment, Flat Rate System		1,000,000.00
Excess interest, sinking fund and depreciation at 9%....		90,000.00
Total yearly excess cost of Flat Rate System...		183,575.00

Meter Installation Cost

In the old part of Baltimore, the unit cost, including the meter, will be about $12.00 and in the annex about $15.50. (These costs should not be borne by the citizens.) Taking this installation cost as $15.50 and assuming there are 10,000 services, the cost will be $155,000.00 on which interest, sinking fund, and depreciation of say 9 per cent, will have to be paid, amounting to $13,950.00, which will reduce our $183,575.00 estimated expenses to $169,625.00 per year. With the installation of meters, we can make a saving in cost of coal, electricity, pumpage and chemicals, etc., of at least 40 per cent of the present daily demand of 110,000,000 gallons, say 30 per cent due to the fact that the meters have decreased the waste of water and reduced pumpage by 33 million gallons daily and its consequent cost. Taking the cost of the filtration at $10.00 per million gallons, which is a fair figure (where accurate records are kept, the cost is found to be about $11.00 to $12.00 per million), we have a saving of about $330.00 per day from this source alone.

Effect of Flat Rates

In Baltimore there are approximately 140,000 total flat rate services. The table below gives the number of each size of dwelling as well as the flat rate charge on a front foot basis.



Curve "A" shows the lack of uniformity as between consumers on this flat rate and curve "B" shows a uniform front foot flat rate to all consumers that would produce the same income.

The rates are not uniform and on the front foot basis they should be. The tabulation indicates that the rate ought to be changed either to a uniform rate of 75 or 80 cents per front foot per year. To set this up in another way the per foot rate is set up, beginning with the highest down to the lowest, again the MEDIAN indicates that the rate falls between 81 and 78.6 cents.

These figures also show that the MEDIAN for dwellings is between 18 and 19 feet, yet these two

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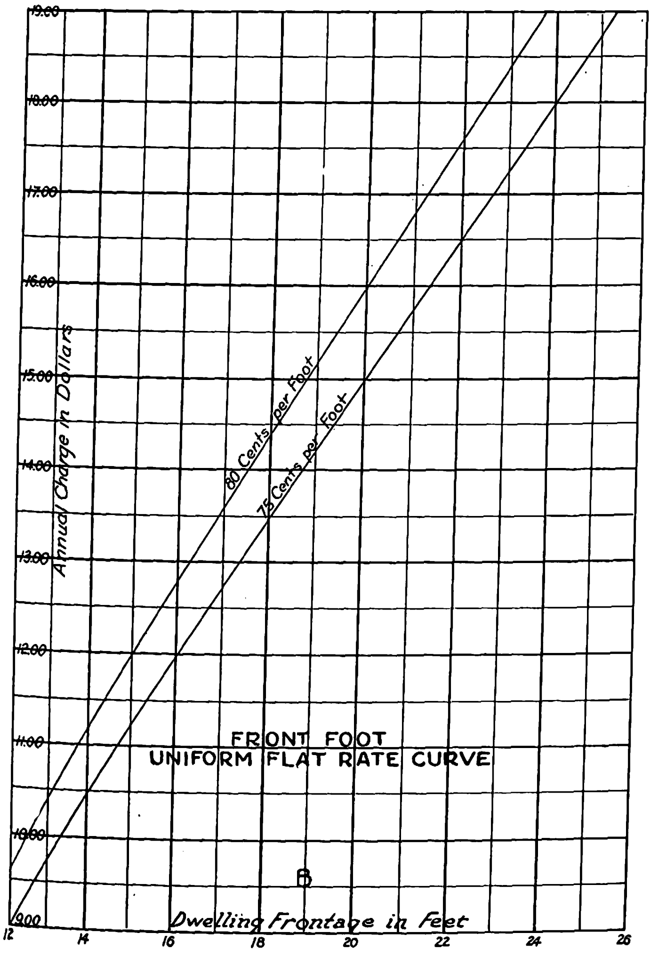
*It is a well known fact that the Pumping Plant investment is usually double that required by the daily demand, due to the installation of double the pumping capacity and an excess investment in purification due to the installed capacity being about 20% over that required.

**The average cost of pumping in the Massachusetts Metropolitan Water District for 1921 was $41.00 per million gallons.

Number of Dwellings	Width in feet	Rate per foot in cents	Annual Charge	Revenue	Equivalent No. of 12 ft. Dwellings	Rate per foot Large to Small
29990	not over 12 ft.	$ .50	$ 6.00	$179,940.00	29990	$1.05
20350	not over 13 ft.	.615	8.00	162,800.00	22046	1.00
31500	not over 14 ft.	.714	10.00	315,000.00	37583	1.00
19131	not over 15 ft.	.734	11.00	210,441.00	23914	.96
10242	not over 16 ft.	.782	12.50	128,025.00	13656	.832
5526	not over 17 ft.	.824	14.00	77,364.00	7828	.834
4744	not over 18 ft.	1.00	18.00	85,392.00	7116	.812
1967	not over 19 ft.	1.05	20.00	39,340.00	3114	.786
4410	not over 22 ft.	1.00	22.00	97,020.00	8085	.782
1979	not over 25 ft.	.96	24.00	47,496.00	4128	.75
1669	not over 30 ft.	.832	25.00	41,725.00	4172	.734
711	not over 35 ft.	.786	27.50	19,552.50	2074	.714
557	not over 40 ft.	.75	30.00	16,710.00	1856	.615
584	over 40 ft.	.812	32.50	18,980.00	1995	.50
		.81		$1,439,785.00	167552	

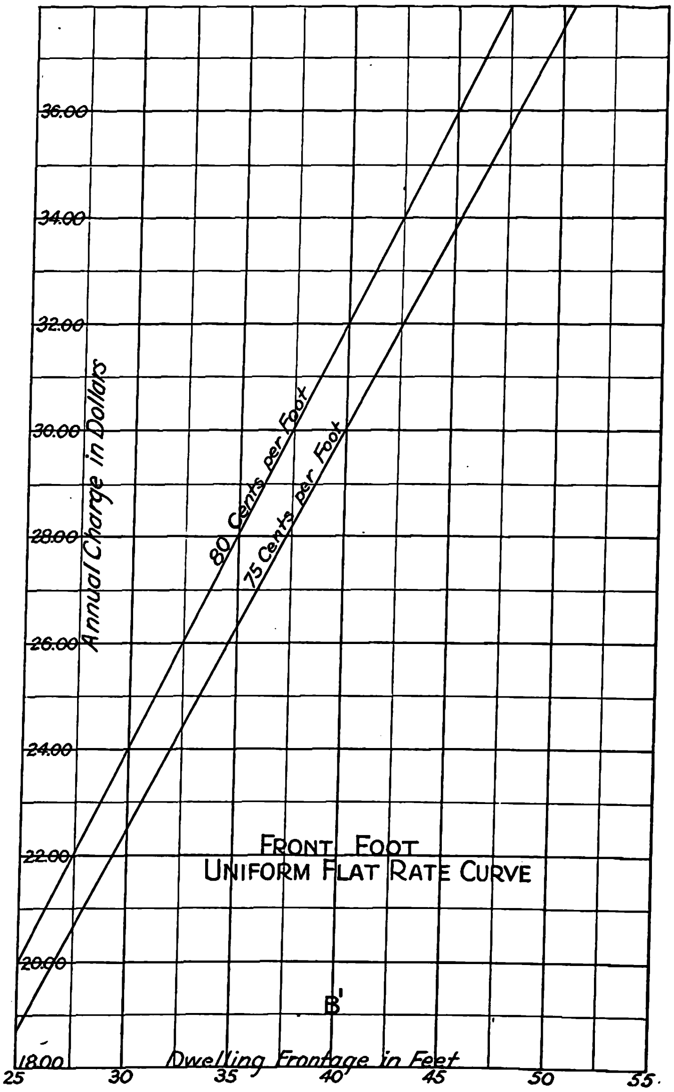
Average Annual Rate 12 ft. Basis $8.59 or 71 Cents per Foot



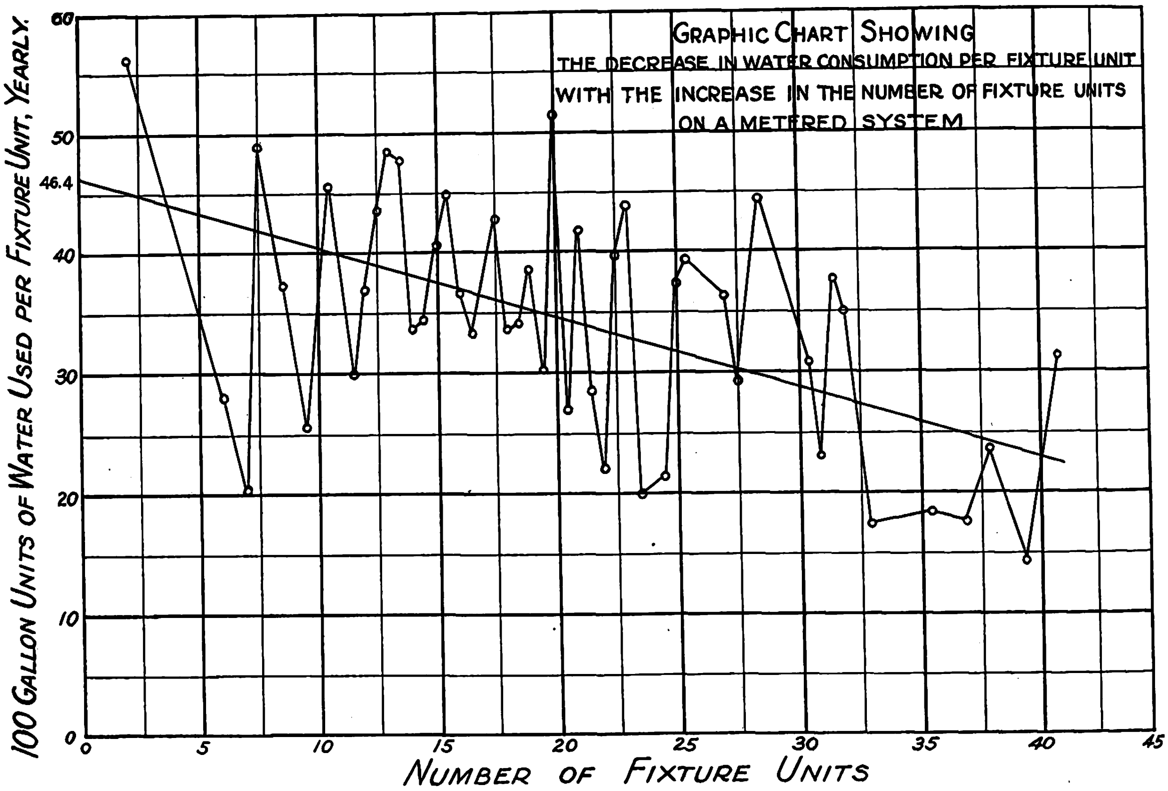
carry the highest front foot rate and it should not be so.

Projecting this rate either at 75 or 80 cents per foot on the curve as here shown provides means whereby the rate clerk can set the proper annual rate for any width dwelling and the rate should be taken to the nearest dollar or half dollar as this makes the work much more rapid and easier.

Curve "C" is a study of the use of water in a



100% metered system and its effect on the sewerage system. It discloses the fact that as the number of sanitary fixtures in a dwelling increase, there is not a direct increase in the use of water in proportion to the number of fixtures, but rather a decrease.



CURVE C

This is true in every case except in industry. A study of the flat rate system indicates that this same condition does not apply on account of the fact that there is no restraining agency, and the repair of leaking fixtures is neglected. You will note that various fixtures have been reduced to a unit basis for determining this condition, as recommended by the Bureau of Standards.

	Fixture Units
One lavatory or wash basin	1
One kitchen sink	1½
One bath tub	2
One laundry tray	3
One combination fixture	3
One urinal	3
One shower bath	3
One floor drain	3
One slop sink	4
One water closet	6

And, as mentioned elsewhere, 50 to 55 per cent of the total water pumped reaches the sewer system. The effect of the installation of meters on this system, in so far as cost and operation is concerned, is easily seen.

Curve "C" indicates that a method for charging for sewerage service can be developed equitably on a straight line basis. While increasing gradually it decreases with the number of fixed units installed.

Estimate of the Cost of the Waste

The cost of the waste for the hypothetical plant was $183,575.00. If the City of Boston with 112 gallons daily per capita, is taken as comparable with Baltimore, there is no reason why the daily per capita consumption in Baltimore should not be reduced at least from 170 to 112 gallons, or about 34 per cent. The cost of this 34 per cent, or 13,774 million gallons yearly, to the citizens of Baltimore, at $25 per million, is $344,435.00. This is a dead loss for which they get not one cent of return. This sum within five years would pay the entire cost of the installation of meters and there would be something to show for the investment.

The estimated cost of $25 per million gallons is too low. It is probably between $40 and $80 per million. There is also an additional cost of handling this waste water at the sewerage plant of about $172,175.00 yearly.

How Water Meters Reduce the Cost of Water

The advocates of a flat rate system, in the light of our present knowledge of conditions to be met in any large city, are really urging the expenditure of large sums of money uselessly. This useless expenditure is a greater burden, on the poorer class of people, in the form of taxes, directly or indirectly assessed, than a higher metered water rate would be. There is no doubt but that a considerable reduction in the tax rate of many cities could be made if the water was sold entirely by meter.

Taking the actual water consumption in Baltimore as 170 gallons per day per capita, it is possible to reduce this by one-half, we will say 85 gallons per day per capita.

Immediately, the capacity of the entire system, water shed and all, is doubled for the same population, and instead of an assumed life of 10 years before additional capital expenditures are required it will be 20 years, or the same capacity would be able to serve double the population. The investment per capita is cut in half and the operating expenses will also be cut in half.

The cost of the wasted water is much greater than the fixed and operating charge of a meter system. The cost of purchasing and installing meters could be distributed over a five-year period in any city; whereas, deferring the use of meters reduces the margin between an ample and an insufficient supply of water, and meters do defer sometimes for many years a large investment in new pumping and storage systems to care for a larger future population.

The city would have protection, in addition, against the cost of handling the extra sewage caused by the present waste. Meters should be installed even with an unlimited supply of water, because it is cheaper to use meters than to do without them, and it costs less money to have water on a meter basis than on a flat rate. Without a meter system to record the amount of water used, and a charge for water by meter based on both fixed and fluctuating yearly costs, there is no incentive for any private, domestic, or industrial customers, or any city department, to avoid waste.

Meters increase the capacity of mains already installed for fire fighting purposes in that they reduce the quantity of water supplied for domestic and other purposes from 40 to 60 per cent, hence increasing the fire fighting possibilities.

How Water Meters Fairly Distribute the Cost of Water

It is impossible to measure, by any known means, services such as police protection, good roads and many other governmental functions, but service in the form of water supplied can be measured directly and accurately and sewerage service can be quite accurately indicated, though indirectly, from the measured water service. Fire protection cannot be measured, but the taxpayer receives a reduction in his insurance due to a water supply that is also some measure of this service.

When water is charged for in the form of taxes, many citizens, who cannot for some reason or are not on the line of mains, are taxed for what they do not get and such a method of charging for water is unfair in every respect.

The method of charging for water through meters is a fairer method than any other system. Water rates cannot be equalized as between occupants of separate houses of the same size, nor as between families of the same size, for the use is different in all cases; and any attempt at equalization that is not based on the amount of water individually used is a farce.

The expense of any water department under a flat rate is now partially met by money received from two sources, (a) the front foot rate and (b) the tax levy that covers the balance of the cost. The use of water meters will decrease the cost of water because part of the cost will be eliminated with the waste, and the revenue from the new meter rate should be less than the sum of the two present costs.

Meters will decrease the tax rate by wiping out the annual deficit in the water department and will decrease the total cost to the taxpayer, equalizing the charges according to the amount used.

The use of water meters will equalize matters in that the annual deficit is now paid in the tax assessment, but not by corporations which are tax free on certain features; the corporations will pay for the water they use on a meter basis. Universal metering should result in taking the cost of carrying the various water loans out of the tax levy as they would be carried by the meter rates when the water department is made self-supporting and subsequent loans would be handled in the same manner.

Now, a word as to the meter rates. A service charge should be made to cover fixed charges such as interest on loans, sinking fund and depreciation and all bills should be made quarterly, for the reason that this tends to hold down the useless consumption. During the summer months when the run-off is at the lowest point and the demand on the system the greatest, this tends to conserve the water supply and reduce the cost to the citizens.

The use of this service makes it possible to take the fixed charges out of the tax rate and charge them against the department responsible for the same, and with the consumption charge will place any water department on a substantial financial basis. The consumption charge is variable from year to year and can be made up by varying the discount in the next succeeding years.

Cost of Setting Meters

The lowest figure for setting available to the writer at this time is for ⅝ meters set in Detroit in 1921, and the highest average cost of meters from ⅝ to 6 inches in the new Baltimore City Annex of 1922. These meters are set in the lawns. The cost of meters installed in the lawns should not exceed $12.50 each made up as follows: Meter $10.00, Material $1.00, Labor $1.50, assuming that not more than two hours labor per meter will be required, which has been found ample in the Baltimore County Metropolitan District.

The cost of setting ⅝ inch and ¾ inch meters on contract for 1925 was $2.80 each, exclusive of the service, meters and iron meter box tops.

The estimated cost for metering of flat rate services in Baltimore has been estimated at an outside figure of about $1,792,000, and on account of the large number to be purchased and set this figure can be reduced.

In reference to depreciation and maintenance of meters it is known that there are meters still in use that are over forty years old and, if a first class meter is purchased and kept in repair, there will be little trouble or depreciation.

Conclusion

Meters stop waste of water.

Meters do not limit the legitimate use of water.

Meters increase the storage in its relation to a given population.

Meters will conserve water resources.

Meters reduce the capital and per capita investment.

Meters make better fire protection possible.

Meters increase the capacity of mains at a cost far below that required for an equivalent capacity in new mains.

Meters reduce the cost of operation of the sewage disposal plant.

Meters mean more water to the citizen.

Meters mean less cost of water to the citizen.

Meters mean a reduction in the tax rate eventually.

One hundred per cent metering will reduce the water to be supplied 40 to 60 per cent.

Consumption of Fuel Oil by Railroads

Railroad fuel oil purchases account for approximately one-fifth of the total fuel oil marketed annually in the United States. During 1925, purchases totalling 70,636,559 barrels were made by the 147 Class I, II and III railroads. The two largest purchasers were the Southern Pacific Company and the Atchison, Topeka and Santa Fe Railroad Company which, with their subsidiary lines, purchased approximately one-half of the total. The efficiency with which oil is used as a locomotive fuel has been increasing steadily. This increasing efficiency has been accomplished through the cooperation of employees in fuel conservation; the application of modern devices, such as feed-water heaters and superheaters, to older power; purchase of new and heavier power, equipped with the latest devices; more complete loading of cars, and improvements in the roadway. Fuel conservation bureaus have been established by several railroads and careful attention is given to locomotive, shop and power plant consumption. Increasing efficiency in the burning of oil in stationary power plants and shops is comparable with that obtained in locomotives. There is at present no uniform national tendency either towards the conversion of coal-burning locomotives to oil-burning or the reverse, as the conditions of use vary with the relative costs of oil and coal in the particular region.

The recent introduction of oil-electric locomotives is a development which is of importance in considering future railroad fuel consumption. This locomotive is a self-contained power unit in which a Diesel-type oil-driven engine operates a generator which furnishes power to railway motors which are geared direct to the driving axles.

This study on railroad fuel oil consumption is the first of a series of studies relating to the consumption of fuel oil in the United States, being conducted by the Bureau of Mines in cooperation with the American Petroleum Institute.

Control of Locomotive Smoke

Locomotive smoke has seemed difficult to control, but many cities in the Middle West have attempted to solve this problem, with more encouraging results than were at first supposed possible. The fact that railroads are operated under more standardized conditions than ordinary stationary plants makes for firmer control of individual employees. In locomotive operation there is authority in the motive power department, which specializes in supervision and has all of the machinery necessary for it ready at hand. Men who work on locomotives are usually more efficient than employees of small industrial plants and respond more readily to suggestions offered in smoke-abatement programs.

In the past 10 years standardized equipment has been designed to reduce the discharge of smoke from locomotives. This equipment includes multiple tip blowers, quick-opening blower valves, and induction tubes in the sides of the fire box to supply the air necessary for complete combustion. Such equipment is simple, is easily added by ordinary boiler makers, and has been discussed in detail in the proceedings of the various railway associations. Literature on the subject is available to all railroad men.

Any locomotive properly equipped with standardized smoke-abatement devices can do its required work without making dense smoke. Experience over a number of years has shown that passenger, freight, suburban, transfer, and switching engines can operate successfully with minimum smoke production and are doing so in the Middle West. Locomotives can be and are operated in all classes of service with smoke densities below 7½ per cent, which generally brings this class of smoke down to a negligible quantity.

The co-operation of railroad executives must first be obtained in order to have proper instructions issued and disciplinary measures put into effect. Where abatement of railroad smoke has been successful, it has been customary to make the road foreman of engines responsible for the smoke performance of the engines under the master mechanic of the division. The organization for doing this is already in existence, as locomotive operation is closely supervised. The best results are obtained by making the engineer and the fireman equally responsible for smoke production; this gains the engineer's co-operation in working the engine and aiding the fireman to build up fires. When engines are equipped with blower valves, these should be installed on each side of the cab, so that the engineer or the fireman can use them when necessary.

Many railroads have found that saving resulting from this supervision more than offsets the cost to the company.

New Coal Developments[*]

By A. G. CHRISTIE,
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THIS address will present some new developments in the use and treatment of coal. For the purposes of this discussion, coal may be described as a mineral substance which is found in nature and which consists of four constituents, fixed carbon, volatile matter, moisture, and residue or ash. In nature, coal ranges all the way from anthracite, which is principally fixed carbon, down through the bituminous coals to lignite, which is largely composed of moisture and volatile matter.

Going back a few years, coal was used largely for three purposes: First, as a fuel to generate heat only; second, as a material from which to make metallurgical coke, and third as a raw material for making illuminating gas. Recently, improvements have been made in all of these three processes, and these improvements will be briefly discussed.

Improvements in Methods of Using Coal

In the first place there have been enormous advances in the last few years in connection with the burning of coal to generate heat and in that way to make power. The strides that have been made in stoker development will be discussed only briefly. Those who are familiar with power plants know that enormous stokers are now operating at high efficiency and are burning fuels which it was not possible to burn properly on stokers a few years ago. Decided improvements are still being made in stoker design and operation. Economies have also been increased by employing pre-heated air, using the waste heat gases to pre-heat the air which is used in the stokers. This also has tended towards increasing not only the efficiency, but also the capacity of the furnace. In the use of stokers there also has been another advance which is economically worth while, and that is the utilization of the ash from the stokers. This is now processed in such a way to remove most of the dust and the fine ash itself. The clinker may be made into cinder blocks. This cinder block is used for building purposes, and many stucco houses are now being built from this cheap material.

Another development in the use of coal has been its use as pulverized fuel, that is, burning it in the powdered form in suspension in the furnace. There are two general systems in use,—the so-called central system, and the unit system. In the central system, the coal is dried and prepared in a separate plant or separate part of the boiler-room, and is then transferred to bunkers over the boiler, from which it is fed by suitable feeders and burners to the furnaces. With the unit system the raw coal is put in bunkers above the boilers. One or more unit mills pulverize the coal right in front of the boiler. The coal runs into the mill, is ground, and carried directly into the furnaces without storing it in the pulverized state. There may be one or more mills for each furnace. The unit system lacks some of the flexibility of the central system, and some feel that it is not quite as efficient. It is much cheaper to construct. Many of the new plants will be built on the unit system rather than the central system. With a little further development in the mills, the unit system can be made quite as efficient as the central system.

The development of pulverized coal made possible higher furnace temperatures than before, and that brought on a revolution in the construction of furnaces. The early pulverized coal furnaces had to be made of enormous size in order to permit the burning of the coal and to keep the fire brick walls from failing. Such construction is expensive. Furthermore, with certain coals, the ash is such that the fire brick will not stand the furnace temperature and would start to fuse and run with the ash. Something had to be done to cool such furnace walls in order to maintain them in service. The first step was air cooling. The air which was used for combustion was drawn around through hollow walls, and then fed into the furnace at the front along with the powdered coal. This air took up the heat transferred through the brick and kept the walls cool. That construction works very well on high grade coals. But with coal from the Middle West, and with certain of the Eastern coals containing iron in the ash, the air-cooled wall may not be satisfactory. It was obvious that some other method had to be devised to meet the situation. That method consists of lowering into the furnace along the side walls and rear, a portion of the heating surface of the boiler. In other words, water cooled walls and bottoms were provided. Different forms of water cooled walls are now on the market to take care of this cooling. The tubes may be exposed directly inside the furnace wall, some refractory brick may be placed between the tubes, or the furnace may have all metal walls. The Murray Fin furnace is one of the latter type. Another form is the so-called Bailey wall, where the water tubes are faced with a cast iron block which may or may not have a refractory facing on the furnace side.

Along with this development in furnace wall construction there were developments in the furnace itself. Engineers have realized that pre-heated air would accelerate the rate of combustion and improve the efficiency of burning powdered fuel. Many new stations are now going into operation with pre-heaters in the flue gases to recover the heat of the flue gases by the incoming air, and in that way improve combustion. Turbulence was also found necessary in the powdered coal furnaces, and that also has improved combustion. A further factor to which engineers only started to give real consideration a few years ago, was the matter of radiant heat. This is the most effective of all forms of heat transfer and had formerly not been given the consideration it deserves. Its value is better appreciated and boilers and furnaces are now designed to take advantage of radiant heat effects. This will also improve operating conditions in boilers and furnaces.

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[*] Address before the Engineers Club, February 8, 1927.

Gas Manufacture and Retorting

Let us turn for a minute to gas manufacture, which formed the second and third uses of the coal. The manufacture of metallurgical coke has been fully discussed by others. Early gas retorts were simply intended to make illuminating gas. The next development was the by-product coke oven, where not only was illuminating gas made, but a coke was produced that could be sold for metallurgical or other uses. By-products in the form of tars and oils were recovered, and these have proved profitable sources of revenue. Another process of great importance is the water gas process. The early water gas processes used anthracite which was brought to a red or almost white heat, and steam was blown through it. The steam was dissociated while passing over the hot anthracite and hydrogen and carbon monoxide were formed. Anthracite went up in price and became dirtier. It seemed desirable to get a substitute fuel for the water gas producer. The next step was to use coke in place of the anthracite in the water gas producer, and many are operating today with coke as the fuel. But coke is a high-priced fuel and within the last few years, a cheaper fuel, bituminous coal, has been employed directly in the water gas producers. There are two processes now on the market which employ bituminous coal directly; the Back Run process, used in the Middle West, and the Pier process, which has been developed in the East. Another development in connection with the water gas manufacture, which has improved the efficiency of operation, and lowered the cost of production, has been the use of waste heat boilers in connection with the water gas generators. These boilers recover a great portion of the heat that is usually wasted in the blow that always takes place in reheating the fuel in the water gas generator.

Reference will next be made to another method of coal retorting which has recently received a tremendous amount of attention, and on which a great deal of money has been spent, both here and abroad. This is low temperature carbonization. These processes attempt to achieve either of two objects—first, to provide suitable smokeless domestic fuel, which may be used in place of anthracite; or, second, to remove the by-products from the coal before it is used elsewhere as a fuel. Rather than discuss in a general way all the processes that are being developed, several American processes will be described. One of these is the so-called "McIntire Process" now operated by the Consolidation Coal Products Company at Fairmont, West Virginia. This company produces a smokeless domestic fuel. Bituminous slack coal is fed into a retort, which is stirred by paddles which oscillate back and forth and work the material gradually toward the discharge end. The retort is heated on the outside by gas, and is brought to a temperature of about 1200 degrees, at which the gas, oils and tars are distilled off, leaving only a small percentage of volatile matter in the coal as it passes out of the retort. Of course, the stirring breaks up this material so that it is discharged in small chunks as a sort of char. The gas can be recovered and used; the oils can be recovered; and the tars can be treated in the usual way. The products are gas, oils, tars and char. The char is subjected to pressure, after being mixed with some waste pitch and oil and formed into briquets. These are put through a second retort which simply drives the volatile matter out of the tar which was used as a binder, and forms the finished briquets. This is the form in which it is proposed to market the material as a substitute for anthracite. It is fairly clean, and hard, and contains sufficient volatile matter so that it ignites easily, burns with a flame about six inches high and does not produce smoke. The present experimental plant is complicated, but it can be simplified by further engineering. It is quite possible that this material can be put on the market at a lower figure than anthracite.

Another process being developed in the West to produce a smokeless domestic fuel is the Wisner process, where a couple of rotary cylinders like cement kilns are used. The coal runs through the first one, where its coking properties are partially destroyed. The residue is heated in the second retort to drive off gas and tar and to produce so-called "coal balls." These can be used as a substitute for anthracite. The fines from the process will be burned in power plants on chain grate stokers.

Another process of interest is the McEwen-Runge process which strips the coal of its volatile matter before it is burned in furnaces. A development plant is now in operation at the Lakeside Station, Milwaukee. In the McEwen-Runge process, two large retorts are used, one above the other. The upper one has a certain amount of heated gas furnished to it, and the powdered coal is sprinkled down through it.

As it falls through this upper retort it is raised in temperature to such a point that it loses its coking property but does not give off gas. It will no longer stick together and swell into large masses of coke. Then it is dropped through another feeder into the lower retort where it showers down through a very hot stream of gas, which distills off the gas and tars. At the bottom it is a char somewhat larger than it started in, but very friable. This material can be used as pulverized fuel under the boilers. An unusually favorable condition exists at Milwaukee because the gas comes off at about 550 B.t.u. and can be delivered into the gas service lines of the Wisconsin Gas Co., which supplies gas to Kenosha and Racine. This provides a ready market for all the gas made. The oils are to be refined. It is proposed to use the motor fuels in the bus lines that the operating company runs around Milwaukee. The tars are to be sold locally. The char will be burned under the boilers in Lakeside Station.

Another interesting process is being developed by the Detroit Edison Company, where the coal is to be retorted by electric heating. It is proposed to use off-peak power to retort this material. The resultant coke will be a good domestic fuel.

The yields of these processes are given in general terms because they will vary with different coals. The average yield is as follows from each ton of coal of 2,000 pounds: 1400 pounds of semi-coke; about 3000 cubic feet of 1000 B.t.u. gas, or its equivalent of about three million B.t.u. in gas, 26 gallons of tars, and four gallons of motor fuel, which can be used in automotive engines. The yield in motor fuel is somewhat larger than in other processes. The tars generally are of cresotic character.

European Developments

General Georges Patart, of France, is credited with developing a process by which water gas can be turned into methyl alcohol, or methanol, as it is now known in the trade. He takes the gas, carbon monoxide and hydrogen, adds some steam to it, and brings it up to the proper temperature and pressure conditions for the first process and passes it through a nickel-iron catalyzer. Half of the carbon monoxide is oxydized by the oxygen from the steam into carbon dioxide, the hydrogen from the dissociation of the steam, staying in the gas. The resultant CO_2 is easily washed out by a spray of water at high pressure and leaves a gas with two parts by volume of hydrogen and one part of carbon monoxide. This gas is raised to about 1500 pounds per square inch pressure, and heated up to about 1000 degrees Fahrenheit. It is then passed through a second catalyzer, which consists of zinc oxide placed in a copper-lined tube. In passing through the catalyzer the hydrogen and carbon monoxide combine to form the methanol, giving almost 100% yield. This process is in operation at the plant of the Badische Anilin und Soda Fabrik in Germany. It is said that methanol can be made for sixteen cents a gallon in Germany by this process. General Patart, stated in Pittsburgh, that he could make it for approximately twenty cents a gallon in the United States. Although a great deal has been written about methanol in the magazines and newspapers as a motor fuel, it has its limitations. Our gasoline or other motor fuels would have to cost about 40c a gallon before it would pay to use methanol at 20c per gallon. Large quantities of petroleum still remain to be recovered and furthermore, after petroleums are exhausted, the oil shales in the West will be commercially available for a long time, and they can be retorted at a lower figure than methanol can be made. Methanol as a motor fuel does not offer great possibilities in this country. The conditions are different in Europe, where motor fuels are higher in price and where they wish to be independent of outside sources of motor fuel supplies in case of another war. However, Patart has pointed out that by modifying his process and changing his catalyzers, or re-catalyzing the material with which he was working, he could get ethyl alcohol, or any of the other higher alcohols at a low cost. Or, by a different catalyzer, he can break down the methanol and get formaldehyde. That offers wonderful possibilities in this country, which makes the process attractive.

Fischer in Germany has developed similar processes for water gas, has used various catalyzers, and has practically duplicated the methanol process of Patart. He has also developed a process by which he can produce a series of hydrocarbons from water gas. He has not been able to separate these hydrocarbons easily, but he has refined them together and calls the resultant material Synthol. Fischer claims that Synthol will serve in place of ordinary gasoline as a motor fuel. He has also operated his Synthol process at atmospheric pressure.

Another interesting development in the use of water gas has taken place in the last few years, namely, the production of synthetic ammonia. The ammonia process operates somewhat as follows. The water gas, hydrogen and carbon monoxide, first is mixed with some air and steam. The whole mass is then put through a catalyzing process in which the carbon monoxide is completely oxydized to carbon dioxide, and washed out. The proportioning is so arranged that after washing and cleaning, there are three parts by volume of hydrogen and one part of nitrogen in the final gas mixture. This is raised to about 3000 pounds per square inch pressure, and put through a suitable catalyzer, and converted into ammonia. This is about the cheapest method that has yet been discovered for manufacturing synthetic ammonia. A plant using this system is already said to be in operation by Lazotte at Belle, West Virginia. The Allied Dye and Chemical have recently announced that they will build a nitrogen plant at Hopewell, Virginia, which will probably operate on this process. Ammonia can be oxidized to nitric acid or to other commercial nitrogen products.

Another process that is rather interesting to engineers, is the production of urea from ammonia. Formaldehyde, which is made from water gas, and urea, which is also made from water gas can be combined to form resinous materials very similar to bakelite or redanol and can be produced cheaply. As a result this process can be used for making furniture trim, which has heretofore been made entirely of wood and for forming many other products.

Another process of coal treatment which has received a great deal of publicity in this country and abroad is the hydrogenation of coal. Dr. Bergius, in Germany, proposed this method and has spent a great deal of money in its development. Dr. Bergius grinds the coal to about twenty mesh size, and mixes it with some tar until it becomes about the consistency of toothpaste. It is then pumped quite easily through tubes under pressure into the retorts. These retorts are of very heavy construction because the pressures and temperatures used in the process are high. After the mixture is in the retort, hydrogen is pumped in at from 1500 to 3000 pounds per square inch. The retort is then heated to about 1000 degrees Fahrenheit. The hydrogen is circulated around until the coal has all been turned into oils, or other hydro-carbon products, by the addition of the hydrogen to the carbon molecules, and only the ash is left solid. The yield from this process according to Dr. Bergius is as follows:—15% of the coal charged is motor fuel, 20% a fuel suitable for Diesel engines, 6% lubricating oil, 8% fuel oil,—totaling 50% of oils,—there remains 20% gas, 7½% water and the remainder, pitch, and ash. On the basis of a yield of 50% as oil, it would indicate that two tons of coal would make one ton of oil. However, besides those two tons of fuel, about .8 ton more fuel must be provided for process power and heat and for producing hydrogen. Hence 2.8 tons of raw coal will produce about one ton of oil. The gas which Bergius generates is put through a catalyzing process with steam and generates hydrogen, so he does not have to go outside his own process for a hydrogen supply. This process sounds very interesting, and from a conservation standpoint, it appears that one is getting all that can be taken from the coal. However, the machinery is extremely expensive, and again, the produce must compete with petroleum products. There is therefore little hope for the development of Dr. Bergius' process in the United States for some time. However, other conditions exist abroad, and it may be desirable in certain European countries to fully develop this process.

There is one rather unusual feature in connection with the low temperature process and the Bergius process. The low grade fuels such as the lignites and the Mid-West bituminous coals, apparently give the highest yields and most economical results in both processes. This is an interesting fact, and indicates that some rather interesting developments may be expected in the Middle West in the use of low grade fuels for many of these processes.

Conclusion

Summarizing the preceding paragraphs, there have been real improvements made in the burning of fuel, both with stokers and as pulverized coal; advances have been made in the manufacture of gas, and the recovery of waste heat in waste heat boilers; new products can be made from water gas; one does not know yet how many different chemicals can be catalyzed from Methanol. It therefore appears that there are wonderful fields open for further development of still other materials that may be manufactured from coal. We are just on the threshold of new and interesting developments in the use and treatment of coal.

Stainless Steel

Stainless steels—steels which resist oxidation and corrosion against most media, contain from 9 to 60 per cent chromium, from 0.1 to 1.0 per cent carbon, and in addition such elements as copper, molybdenum, tungsten, nickel and silicon. The special properties which the steel possesses are due not only to the chromium and carbon content, but also to the peculiar heat treatment to which it is subjected, after its manufacture.

Although these steels had their origin as early as 1820, their value for everyday use was not appreciated until 1913. Since that time, however, they have been widely applied and their use is now becoming quite general.

The present bulletin is arranged in four parts in order to be of service to four distinct classes of readers. The digest, which sketches briefly the facts regarding stainless steel, will be useful to those who desire a condensed statement of the whole story. The abstracts of important articles on stainless steels will serve those who wish to read the evidence of the original authorities on the subject without themselves going into an exhaustive search of the literature. The bibliography, which has been brought down to the date of publication, will greatly economize the time of those interested in carrying on further research on stainless steel. The graphical studies will, it is hoped, give the technical man, accustomed to the interpretation of such material, a rapid survey of the subject.—Engineering Research Bulletin No. 4, University of Michigan.

Strengthening Highway and City Street Foundations to Meet the Increase in Motor-Bus and Truck Traffic*

JULIUS ADLER,
Presiding Officer, Afternoon Session

THE subject which we have before us this afternoon, in line with similar subjects which the Engineers Club has sponsored in connection with its meetings in the past, is a specific one, touching upon the highway situation today, rather than an attempt to cover the entire field, which manifestly is hopeless, in the limited time at our disposal, and which is being so fully covered at the various national meetings today. It would seem to me that in the attempt to cover this subject it can very well be subdivided into three portions, the first of which would be the discussion as to the real necessity confronting engineers in the highway field for the strengthening of foundations for roads and pavements of whatever type; the second would be a determination of the various methods available for such strengthening, and the third would be a comparison of the merits of the several methods for strengthening. Our program is arranged in general on that basis, though we start with the assumption (which may prove incorrect) that there will be a strongly developed opinion in favor of the necessity for strengthened bases.

Methods of Strengthening Paving Foundations

By **FREDERICK W. LYONS,**
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THE primary factor in construction of any structure subject to impact, vibration or heavy loading is a thorough, painstaking and, if necessary, expensive preparation of the sub-grade or sustaining soil.

In briefly discussing this problem I will cover the following points, which I believe pertinent to proper practice in the construction of street foundations.

1. Preparation of foundation.
2. Study of traffic which may logically be anticipated.
3. Section of base and the obtainment of maximum resistance to prospective loading.
4. Financing of abnormal expenditures for street improvement.

As to foundation, we all agree, I take it, that a roadway or street constructed on 100% theoretically unyielding base would result in ideal results with a base having a cross section much thinner than now found to be normally necessary.

Unfortunately we are most infrequently unable to obtain even the approach of a theoretically perfect sub-base, and in view of this, it has been my policy to pay most particular attention to the preparation of sub-soil where streets are to be laid, first, as to drainage; second, as to compacting, and in case of failure to obtain proper compacting, the introduction of stone or gravel or other pervious aggregate in such measure as to insure as near a solid sub-base as is possible of attainment. It is my opinion that any economy practiced in the preparation of base is false and the question of financial expenditure should never be considered.

The second point, namely, the study of traffic which may logically be anticipated, and upon which to a certain extent the cross section of the base is predicated, is one that, of course, hinges upon the general knowledge of the designing engineer of the locality and the amount of traffic which is existent at the time and which may logically be expected to either increase or decrease both as to volume of vehicles traversing the thoroughfare and the tonnage carried. There is also for consideration the feature of future availability of the thoroughfare for extensive maintenance repairs; the point being that it would be inadvisable to lay down a light base on a street in a busy section of the city, which was at the time lightly loaded, but which might easily become a heavy through thoroughfare. Many city engineers have been subjected to much criticism by business interests on streets which they have, as they thought, economically improved, and then in a comparatively short time been forced to reimprove due to the failure of the original base, causing inconvenience and loss of business to the abutting owners.

In considering section I find that there is some divergence of opinion among engineers as to the respective damaging influences of extremely heavy loading as compared to a great volume of lighter traffic. I am not prepared at this time to offer a definite statement as to which is the more detrimental, although I might say that from personal observation I know that when a street pavement begins to ravel, the impact of comparatively light traffic has a tendency to rapidly increase the size of the failure and builds up expensive maintenance repairs and an inconvenience to the free passage of traffic.

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*General Subject at Engineers Club meeting, February 15, 1927.

The third point, the laying of a base, whether surfaced or unsurfaced, which will provide the maximum resistance to loading. The first point, of course, under this heading is the obtaining of as nearly perfect materials of concrete as possible. In Pittsburgh we have instituted a system of rigid inspection at the floats of sand and gravel used on city work.

A colorimetric test is made at the floats of all sand furnished, and these tests have resulted, we believe, in the obtainment of much better concrete.

Gravel we have not yet been able to test as thoroughly as might be desired. We do, however, inspect it carefully as to gradation and the presence of foreign matter and flats. I might say at this time that the producers of both sand and gravel on the Allegheny, Monongahela and Ohio Rivers are co-operating with us in obtaining the cleanest possible grade of sand, and a gravel as perfect in respect to cleanness and gradation as the localities will permit. Practically all of the producers have recently installed modern and expensive river equipment and are really furnishing us with high grade material.

Due to the economic factor, we use in Pittsburgh but little crushed stone for pavement foundations. In fact, the only instance which we can cite of recent years is that of the Mount Washington Boulevard now under construction, which is a reinforced concrete highway.

Having obtained the best, and most economical aggregates for concrete base, the remaining points are the determination of the thickness of the section, whether it be reinforced or plain, and the methods of mixing and laying.

In general, except on those streets or highways where it is positively known that no pay-cuts will have to be made, we advocate the use of plain concrete. There is scarcely a city street that will not at some time or another be subjected to pay-cuts or the installation of, or repair to, public utilities such as gas, water, sewer, telephone conduits, etc.

The patching of these pay-cuts has always been a sore point with me. Where a street is surfaced with asphalt or stone block on a concrete base we have rehabilitated the base by means of an overlapping section in a horizontal plane and an increased vertical thickness, afterward covering with the same type of surfacing as was previously taken up. Until recently I was by no means satisfied that even these patches were satisfactory and would not encourage or advocate the use of concrete streets unsurfaced. However, since a recent visit to Chicago and information derived from other sources, I am of the opinion that plain concrete street paving is entirely feasible and economical. It is not believed, however, that reinforced concrete street paving is proper upon city streets due to the fact that the section is designed for its ultimate integrity on the reinforcement and any pay-cut disrupting this reinforcement, of course, ruins the theoretical stability of the pavement.

Observations made during the past several years lead me to believe that the time has now arrived for the couching of specifications to the water cement ratio basis, leaving out quantities of aggregate; in fact, disregarding aggregate except as to its physical characteristics which include, of course, both size and gradation of sizes.

In Pittsburgh the thickness of base ranges at present from eight inches to ten inches in thickness, using a 1:2:4 mix, although as aforementioned, it is our intention to revise our specifications to lay base on the water cement ratio specifications.

The fourth point which I desire to bring to your attention and request co-operation in is that of obtaining legislative action to bring about reimbursement to the various municipalities for their disbursements in street bases which are necessitated for the general welfare rather than the specific municipal requirements. Insofar as Pittsburgh is concerned, and I think the same is true of most municipalities, at least of this commonwealth, all original street improvements are assessed directly against the abutting property owners, and it scarcely appears equitable to lay on a residential street a concrete base thicker than that which would be adequate to carry the traffic reasonably to be expected. We are, however, forced to lay a base of sufficient section to take care of the abnormal 1% in order to have a lasting highway for the remaining 99%. Construction to meet this 1% heavy loading seems absurd, yet must be adhered to. Assuming that we embrace such an economically unbalanced procedure as to construct all streets for the heaviest possible traffic, then ways and means must be devised at no late date whereby maximum tonnage vehicles are taxed in proportion to the street expenditures they cause the municipalities, and a portion of funds so derived be returned to the municipalities involved.

There is also the problem of traffic regulation. This primarily is a problem for the traffic engineer, but we can all readily see that thoroughly enforced traffic regulation will have a distinct bearing on design of bases.

DISCUSSION

COLONEL COMPTON: I would like to ask Mr. Lyon, in using a 1-2-4 mix, or approximately so, in his concrete base for an asphalt pavement, if he has any trouble with it causing cracks. My experience is that the richer you make a mixture, between certain limits of course, the more cracks you have. I would like to ask Mr. Lyon, with the extreme temperatures in Pittsburgh, if he had any of that trouble.

MR. LYON: We did have some thermal cracks, because of which we have adopted a curing method. We cover all our pavements, even the base that is to be surfaced, with either straw or burlap, and in this way we have been able to circumvent that tendency to a great extent.

MR. ADLER: For the sake of clearing up further discussion, I believe that the meeting would be interested in knowing definitely whether you are employing nothing less than eight inches in thickness of base at the present time on all streets which are to be surfaced with asphalt, brick or block as distinguished from a concrete paving, and, if you are employing as great a thickness as ten inches, whether you could give us an idea of approximately what proportion of your work would involve as great a thickness as that.

MR. LYON: Of course we have numerous six-inch bases in the city that were laid prior to the present volume of traffic, but practically all of our present design calls for an eight-inch base, even with the 1-2-4 mix. There are some few streets, probably not more than 5%—with six inches and 1-2-4. Our standard is substantially eight inches, 1-2-4, and our 9″ and 10″, or say 10″, are on heavily traveled thoroughfares.

MR. ADLER: I believe you stated you are not employing reinforcement on any pavements of that type, that is, where there is surfacing.

MR. LYON: I do not advocate the use of reinforced concrete base, or pavement, anywhere on a city street that may at any time possibly be open to pay cuts, because as long as you are depending for the integrity of that base on reinforcement, and have to cut into it, there is no possible way that I can see of rehabilitating that particular base as far as its reinforcement goes.

MR. SKILTON, of Hartford, Conn.: I would like to ask Mr. Lyon what he would do in the case of a different kind of subgrade. I take it the subgrade is pretty much clay in Pittsburgh. We have a situation in Hartford where three-quarters of our streets have soft clay subgrade. I would not dare use 1-2-4 without reinforcing. You say you wouldn't advocate reinforcing at all?

MR. LYON: I would not if I could possibly get away from it. In Pittsburgh, we have everything, even quicksand; we just improved a street on quicksand, and I thought I would have to drive piles and put a concrete mat over it in order to get a job. But I finally got away from that by doing the thing I suggested in my paper—forget expense,—and in places I excavated to a depth as much as six feet below subgrade, and filled it in with stone. And by the way, we have a laboratory inspection made of all stone used in sub-grade fills. So much of it is nothing but indurated clay, you might say, and disintegrates as soon as it gets into the water. We insist on a real stone, fill it in, and get as near a perfect mass as it is possible to get. If you cannot put your sub-base in such shape as to support a plain concrete slab, then your reinforced concrete slab will be only a waste of money.

MR. SKILTON: In Hartford, instead of digging out the softer material underneath, very soft clay, we thicken our concrete and put in very strong steel reinforcing. We have in some instances used a double ⅜″ rod in reinforcing.

MR. LYON: That is a very fine thing if you have no pay cuts.

MR. SKILTON: We consider the pay cuts a very minor thing in such cases.

CLARENCE D. POLLOCK, Consulting Engineer, New York: This is a very important subject and requires very careful study. Considerable study has been made, but more should be given it. By foundation we should not only consider the base for the pavement, but also the soil beneath, as that must ultimately bear the loads passing over the pavement. The base of the pavement should be sufficient to transmit the load on the pavement surface to the subgrade without material deformation and distribute the load over a sufficient area of the soil so that the intensity of pressure will not exceed the safe bearing power of that soil.

Where the sub-soil is sand, or other good porous and granular material, a base of six inches of Portland cement concrete, mixed in the proportion of one part cement to three parts of sand and six parts of broken stone or gravel, is ample for modern traffic, but the situation is different when the soil consists of clay or other material which may become plastic and not afford sufficient support for the base of the pavement during at least part of the year. Constructing a greater depth of concrete will help in spreading the load over a greater area of the soil, but it is expensive and if the soil is one which has a considerable volume increase with the increase in its water content, it will not materially help matters as the thicker concrete will heave about as readily as the thinner. If instead of increasing the depth of the concrete under such conditions, a layer of the clay or plastic material be removed and replaced by a granular and porous material such as sand, gravel, crushed stone, slag or the like, and the concrete foundation is built upon this porous layer, it has been found that the sub-soil does not swell and heave the pavement. This granular course not only provides drainage, but distributes the load over a larger area of the sub-soil, similar to the ballast under railroad ties; also it decreases the friction on the under side of the concrete and thus helps in preventing the formation of cracks. Then, again, it has been found that with clay against the under side of the concrete, even with very small differences in temperature between it and the concrete, there is a condensation on the under side of the concrete which in cold weather freezes and thus adds to the volume increase, and consequent heaving of the pavement. With the granular layer between the base and the clay sub-soil there is no condensation on the bottom of the concrete and thus this trouble is avoided.

Other methods for improving the clay sub-soils have been tried, such as using drain tile, also a combination of drains and a thin cushion such as one inch of sand, etc., but not always with success. The speaker has met with uniform success in the use of the granular porous layer over a long period of years, varying the thickness of the layer in accordance with the soil conditions. In heavy clay or adobe soils which open up wide cracks of three, four or five inches when they dry out, the layer should probably be five or six inches in thickness, but with other clays three and four inches have proven wholly satisfactory. For example beginning some ten or twelve years ago, Mr. P. L. Brockway, City Engineer of Wichita, Kansas, used a layer of four inches of porous material with entire success, but four or five years ago he decreased this to a thickness of three inches, and so far this has proved satisfactory. With some clays a two-inch layer has been satisfactory, but because of the difficulty to obtain a uniform depth with so thin a layer it would seem to be wiser to use at least three inches of porous material.

The speaker was accorded the privilege of looking over the replies to a recent questionnaire of "Public Works" of New York, in which questions were asked concerning sub-grade troubles and remedies tried for their cure. In replies from some 600 cities, 128 reported troubles from sub-soil heaving and 27 reported trouble from contraction cracks in the soil. Some of the latter were also in the former class. This shows of what general interest this subject is. About 80 cities had tried various remedies with more or less success. In about 30 cases some form of porous layer had been used and these were reported as successful where more than just a cushion course was used. It is pleasing to see that so many engineers are trying to work out remedies for this sub-soil trouble and not just blindly jumping at the conclusion that the remedy is a thickening of the base of the pavement.

A Survey of the Paving Situation

By J. H. NEESON,
Chief, Philadelphia Bureau of Highways

THE earliest information we have relative to streets in Philadelphia are complaints made by grand juries beginning in 1705 down to 1720. In various years during this period representations were made to the City Fathers of "bad places," "low, dirty places," "encroachments by property owners," "difficulties with water courses," "lack of paving in the kennels (gutters)" in such prominent streets as Second Street, King (now Water) Street, and High (now Market) Street. We gather from inference that prior to 1720 some few gutters were paved. Complaints from taxpayers were as vigorous, and sometimes as caustic, as they are today; until an accident to a prominent citizen who was thrown from a horse and broke his leg, determined that a paved street should be constructed of pebbles (cobbles) in Second Street from High to Chestnut Streets. This appears to have been decided upon by the householders in executive session at the Leather Apron Club and to have been paid for by public subscription. Two hundred and seven years ago the Minutes of the City Council indicate that the inhabitants recommended "an ordinance to restrain the weight of loaded carriages passing over the pavement." The subject under discussion here is not altogether new.

In 1768 a lottery was instituted and the proceeds of over five thousand pounds were devoted to paving streets and making other improvements. Little information is available in relation to paving done after the Revolution until about 1830, when the excellent streets and foot pavements appeared to have given the City a rating of distinction. Cobble was the prevailing type, but an ordinance approved April 27, 1854, introduced dressed stone on Delaware Avenue, followed by one of June 12, 1868, authorized the laying of approved cubical blocks in central city streets of specific dimensions placed upon "a bed of clean, anthracite coal ashes, gravel and sand." We are not unacquainted with the vintage of the years that followed.

The Chief, Bureau of Highways, in his Annual Report in 1891, describes the effort made that year to secure better results in street paving and recommends that "the base of the paving material should be either broken stone, screenings or a material that will retain the least water, or *concrete* that will exclude moisture from it." He further states "all improved street paving in a city should be laid on a concrete base, which when properly placed is permanent for the renewal of any paving surface upon it." Ordinances were approved April 7, 1893, requiring that a specification concrete of four inches in depth under brick paving and six inches in depth under granite block paving shall thereafter be used on city contracts. In that year the paving of Broad Street was completed between Fitzwater Street and Passyunk Avenue with asphalt "upon an 8-inch concrete base."

In 1891 there appeared to be 756.78 miles of paved streets in the City, none of which was on durable foundation. The history of permanent paving begins 1892-93, and by December 31, 1912, over a period of twenty years, there had been laid according to the records only 358.08 additional miles, making a total of 1114.96. There is no doubt of the inaccuracies of the paving data kept by the Bureau in the early days and there must have been an error of 100 to 300 miles in the records beginning as far back as 1890 and persistently carried forward until the latter year. The record by actual survey *compiled in 1912* is known to be accurate, but reference to the Annual Reports before that time to 1890 shows that at least 450 miles of new paving and repaving was laid down. The quantity of new paving placed between 1892-1912 was limited mainly to the demands of building operations with extensions included, at the instance of the Department of Public Works, for tying in existing thoroughfares or projecting streets through areas which had been developed by operators with all underground structures in place, at an average rate of about fourteen miles per annum. In the same period less than one hundred and thirty-two miles were repaved, an average of slightly over six miles per annum.

The situation created by the demand for additional housing facilities after the War gave impetus to new paving and in the period between 1918-1926, inclusive, slightly less than two hundred miles of original paving was laid, or about twenty-three miles per annum; two hundred and twenty miles of streets were repaved, an average of 24.5 miles per annum as contrasted with the low average of fourteen and six, respectively, in the decades before and after 1900. In these latter years the Bureau constructed or supervised under private contracts, original paving and repaving representing an outlay in public loan or private funds of $25,550,000.

The repaving situation was in dire straits after the War. Lack of foresight coupled with the obsolete methods of financing for repaving, restrained the activities of the Bureau maintenance forces, which for at least ten years prior to that time kept the streets in fair condition for travel only with difficulty as will be seen from the above mileage of repaving figures quoted. Comparatively few thousand dollars were expended annually, funds being provided from current revenue. In 1917 the City was credited with 1176.650 miles of improved pavement, which is not to be confused with wearing surface laid on concrete base, since these figures included all types exclusive of dirt roads. It is not possible to estimate that there were more than 620 miles of paving, including original and replacements on concrete. The estimated balance of 556 miles of streets represents thoroughfares of granite, brick or other form of block laid on gravel or sand foundation plus so-called "improved paving," which according to ordinary methods of reckoning should have been replaced prior to that time. In spite of the re-building accomplished between 1918 and 1923, the mileage of replacement in the latter year made necessary through the amortization of the first streets built on concrete, but mostly broken stone base, remained practically the same; in fact it increased from 556 to 583 and these secondary replacements must hereafter be taken into consideration in repaving programs.

Probably no other city in the country found itself with streets and roads so depleted in strength following the voluminous and weighty traffic they were obliged to carry during and after the War. To overcome this deficiency in modern street construction, it was necessary to secure a different method of financing. An Act of the legislature in 1919 permitting the City of Philadelphia thereafter to issue short term or fifteen-year bonds for the purpose of repaving, and up to and including the year 1926 $13,638,300 has been expended on repaving from funds secured by electoral loans. The funds made available are not ample for our demands.

This brief resumé of the situation as it affects Philadelphia is given here in order that we may have a conception of the balance between paving with and without the support of permanent foundation. In other words, all of the breaks, holes, and depressions one sees on the streets in this City do not exist because of the failure of concrete base.

On such streets where there is evidence of base failure of the street paving, beginning with the period about 1912, when the Bureau of Highways was placed on an engineering basis and its specifications standardized, to what agency or agencies can such failure be attributed? For the purpose of this discussion, we have discriminated between streets occupied by railway tracks and those that are not. Since the underlying causes of failure may be and are different we have confined the discussion to streets on which street railway structures are non-existent.

Failure of concrete base can be attributed to any one or a combination of the following causes:

(a) Inadequate preparation of subgrade;
(b) Imperfect and improper replacement of ditches and service cuts;
(c) Inferior concrete;
(d) Inability or failure of the top surface to perform its proper function.

In our judgment, too much stress cannot be laid on the necessity of properly preparing subgrade for concrete foundation if it is to be expected to accept the uniform distribution of the loads applied to it directly, or transmitted through the base foundation. Particular care should be given to this feature of the construction not only prior to the placing of concrete, but during that operation. The existence of any soft, spongy or loosely bound areas will be as fatal to the life of the concrete base as neglect to replace in the most efficient manner the fill in trenches opened for underground services in advance of the paving or in checking up on older cuts. Lack of the fullest recognition of these important factors has contributed to the failure of street paving in this City and it may be said to be relatively true elsewhere.

In an effort to remedy these causes for defects we have only recently included in our specifications the clauses that all backfill in open or recently refilled ditches, whether high or low, must be replaced by mechanical tamping. This is intended to cover also the areas referred to, that in the operation of subgrading are found to be insufficient to withstand the strain of applied rolling loads.

Practically in all contracts for paving or repaving the engineer must contend at some time or other with a condition known as wet subgrade, a difficult feature to control. Much reliance has to be placed upon the judgment of the engineer and the inspectors in charge of the work; hence the human element enters into the determination of fitness or unfitness of the subgrade. The tendency, which is natural, is to proceed with the placing of concrete in order not to delay the progress of the work or perhaps to anticipate another change in climatic conditions. It should be an elementary rule in good construction work to mark an interruption at this point if it is to be considered of prime importance that subgrade shall be thoroughly dried out. No criticism can be directed either at the contractor or the engineering forces for this character of delay even though by taking chances the work may be expedited. The added insurance of competent paving work should be a sufficient offsetting influence against a mad desire to secure quantity at the sacrifice of quality performance.

It is obvious and would seem there should be no disagreement regarding the most vital element entering into street paving construction—the preparation and placing of concrete foundation. Since its introduction engineers, laboratory and chemical analysts have concentrated their efforts upon the values of mixes and aggregates that enter into composition concrete. But we still find evidence of paving failures traceable to base deterioration. If, as has been established by years of experimentation, pre-cast concrete specimens of given depth and diameter do withstand minimum breaking loads per square inch of bearing surface, should such failure be attributed to the known and accepted traffic loads of today? It is, at least, questionable. The debatable accuracy of physical tests of poured concrete, as now generally made, results not only in none too dependable classification but is frequently misleading in showing abnormally wide ranges of values in one operation, thus leaving the matter open to a number of conjectures. There is need for more accurate and satisfactory methods in physical tests of set-up concrete in place—one that will more reasonably determine at once the worth of the slab—without resort to chemical analysis except as routine check-up. Attention being directed to the modulus of rupture theory in slab or base concrete through work being done by the Pennsylvania Department of Highways and by other testing engineers, may result in the abandonment of present practice. But, if the physical laboratory test does show beyond question of doubt that the concrete specimen breaks at or below the minimum accepted requirements, and chemical analysis indicates a lack of proper proportioning or the absence of cement and aggregates, we are face to face then with a serious defect and perhaps defection upon the part of those in responsible charge of the work.

How do such situations arise? Briefly, they may be summarized as due to inherent weakness of cement or of sand or gravel or stone; too hasty mixing; to poor workmanship in placing; to the excessive use of water; to ignorance or inexperience on the part of the inspector; and finally, to deliberate collusion on the part of the inspector and the contractor or his representatives.

As a contribution to this discussion the Bureau of Highways within the last fifteen days has made examinations on eleven streets placed between the years 1913 and 1926, where we had reason to believe base failures might exist. A total of twenty-seven openings were made and it developed that in eight cases the failures were surface failures only and the base concrete was intact; failure in four other instances was found to be due to improperly tamped ditches in advance of placing concrete; three others were evidently caused by poor subgrade condition; in two instances the concrete base, laid in 1913, had been shattered and from our knowledge of traffic conditions over the street in question, this was due to impact transmitted through surface wear-outs, which the base was unable to withstand. We very frankly state that, broadly speaking, ten of the twenty-seven openings made revealed evidence of poor concrete. Five of these locations were in one street of considerable length and while there were extenuating circumstances in the way of weather and grade conditions, we must reach the conclusion that in the particular locations opened the concrete was of an inferior quality since on all sides of the opening the concrete was of good quality. Those spots that failed evidently were "lean" and caused by lack of cement or overloading of coarse aggregates, improper water content or too hasty mixing..

The conclusion is upon observation only, as no chemical or physical tests were made; no doubt one, or a number, or perhaps all of the facts enumerated entered into the disintegration of the base. The incident is brought forward here to illustrate the importance of the relationship between the municipality, the contractor and the inspector, and the necessity for intelligent co-operation. It has been the writer's experience that the great majority of responsible contractors do give a dollar's worth of work for the dollar received, and we have furthermore encountered only on rare occasion the inspector who is willing to stand by and tacitly agree to a flagrant violation of the specifications. The first requisite of a good inspector is fidelity and loyalty to the responsibility imposed on him.

Rather than place too much emphasis on the lack of cement or disproportioning in cases not proven, our observation has been that in the effort of the contractor's organization to make yardage, there are occasions when good workmanship is sacrificed. Mechanical faults creep in. Water is on occasion too freely used with a consequent sloppy mix; the period of mixing is not given the attention it deserves —a fact that is quickly demonstrated in the looseness and ravelling of the concrete in drying out. A check-up on 60 per cent of the contracts in operation in the month of July, 1926, by an engineer observer of the Bureau, showed that on one-half of these contracts insufficient attention was being paid to water content and the average time of mixing was about 45 seconds instead of 60 seconds called for in the Philadelphia specifications, conditions which immediately were corrected. Assuming that all the necessary quantities of ingredients have been used and in the proper proportion, the strength value of concrete depends almost entirely upon the mechanics of mixing and placing. The time element can be readily controlled and the specifications of the Bureau of Highways for 1927 do not permit the use of a mixer not equipped with a timing device. The variation in time of mixing in ten other cities is illustrative of the differences of opinion of specification makers: New York, Washington, Detroit, Cleveland and Baltimore require the same period as Philadelphia—60 seconds; Chicago, 50 seconds; Boston and Newark, not specified; while Pittsburgh and Buffalo represent the extremes—90 and 38 seconds, respectively.

As in the case of timing, there is no common standard adopted by all of the eleven cities mentioned regarding the period of protection of new base from traffic. New York, Newark, Buffalo, Boston and Baltimore do not specify the number of days; Washington requires four; Chicago, Cleveland, Pittsburgh and Philadelphia call for seven, while Detroit seems to be taking extraordinary good care of newly laid foundation by putting up the bars against traffic for fourteen days. This feature seems to be either over or under-stressed; fitness to proceed has been regulated mainly by experience and judgment, without resort to any scientific principle. To the sinister influence of climatic changes and speed may be charged reasonable doubt of the maturity of some of our base foundation, less important perhaps than other factors, nevertheless cumulative in the final analysis. Again the fixing of a water-cement ratio should be helpful in removing "greenness" or "ripeness" from the speculative field. The water-cement ratio now featured in the discussion of concrete as an index to the ultimate value of concrete for plain foundation, ordinary building construction or more intricate bridge work, may have an important function to perform in paving base of the future.

The increase in the volume, weight and speed of vehicular traffic, particularly motor trucks and buses, is bringing out more pointedly the close relationship existing between the wearing surface and base foundation. Modern traffic insists that the surface paving perform an efficient manifold service—comfort, appearance and ease of cleaning, but, primarily an ample protective covering for the base. Satisfactory wearing surfaces either for economy or expediency have been practically reduced in the cities to two types, dressed granite block and asphalt. We have shown in the recent investigation that the disintegration of base concrete in two selected cases was due to the failure of the wearing surface. Every pot hole, depression or minor break not only is a potential menace but if actually allowed to go on without being repaired must eventually cause damage to the foundation from the impact of dropping loads. It is obvious then that the wearing surface should be smooth and substantial; it will give service and function properly only in direct ratio to the attention it receives from the maintenance organization. Dressed granite block has shown most satisfactory results in serving modern requirements in this City and has afforded a sufficiently smooth running surface. It has been expedient and economical to use this type of surface in Philadelphia because of the large mileage of streets already covered with granite block on gravel base, permitting the redressing of selected block. With a high resistance to displacement and greater adaptability to uniform distribution of loads, we have found very little evidence of base disintegration under block, except that attributed to poor subgrade, or in ditches and cuts replaced some time after repaving. We endeavor to repave in kind—block for block—but expediency also requires that a balance be maintained between block and asphalt, including sections of our main-travelled thoroughfares in repaving programs. Asphalt, although used exclusively on new paving operations, is less hardy than block and shows more quickly the devastating effect of heavy loads. In a greater measure than is the case with granite block, the life of the wearing surface is dependent upon prompt maintenance repairs, although in our investigation we found only two instances where disintegration, or possible neglect in making prompt repair, was the direct cause of shattering of base. But observation alone, irrespective of the type of wearing surface, will demonstrate the futility of preserving base without periodic maintenance patrol.

In the above survey we have endeavored to outline what appear to be the major causes for base failures, endeavoring to suggest the corrective measures that might be applied. It seems to be generally recognized, however, that a change may have to be effected in the character of concrete base or improved methods employed to guarantee against failure during normal life. The principal suggestions so far brought forward are in increase of two inches and upwards over the commonly accepted depth of six inches, strengthening of the mix and the resort to reinforcement. The latter idea will not find favor in many municipalities at least not until the day arrives when city streets are laid out boulevard fashion, permitting the placing of all subsurface structures in the footways or allocated unpaved areas in the roadways. To a limited extent placing of reinforcement in base foundation should receive serious consideration. The tendency of track structures, particularly intersection crossings, turnouts and switches to cause paving defects, and consequent irreparable damage to base concrete, would seem to warrant in special cases of this kind the use of reinforcing material, not only to protect the base itself but the substructures passing underneath; otherwise, the necessity for intermittent opening up of street paving, and the difficulty of replacement from the engineering standpoint, does not appear to justify the increased cost of this type of construction. Not one of the eleven cities heretofore mentioned has adopted reinforcement in city street paving. The use of reinforcement may, however, shortly become desirable in the replacement of concrete over service cuts and ditches, unless methods now employed to guarantee stability of the backfill prove to be more satisfactory than is the case.

A higher powered mix, at increased initial cost, may indicate the trend of thought in some cities as the following data shows:

Mix	
1:8	Buffalo
1:2:3 to 1:3:6	Chicago
1:6	Cleveland
1:2:4 to 1:3:6	New York
1:2:3	Pittsburgh
1:2.5:4.5 (stone or gravel) and 1:2.5:4 (slag)	Detroit

A survey of these eleven cities shows that only two to date have incorporated as a requirement of their specifications eight-inch concrete base, namely: Buffalo and Detroit; New York, Philadelphia, Pittsburgh, Washington and Newark still maintain the six-inch depth; Baltimore, four, five or six; Boston, Chicago and Cleveland have specified no depth, evidently with the thought of meeting special or variable conditions. Nevertheless there is a growing disposition in the belief that increased depth of base is the solution of the problem. It may or may not be. But in the belief that we must provide extra depth of base if we are to have future security in the soundness of our foundation paving, Philadelphia completed two major repaving projects in 1926, one in the water front section where traffic is not only congested but heavy, and the other on a heavily travelled truck, touring car and bus route, using eight-inch base concrete. Experience has demonstrated, granting that all possible care has been taken in the preparation and placing of 6-inch foundation, that failures do occur. An increase in the factor of safety is inevitable and for that reason we believe we were fully justified in absorbing the additional cost on these operations.

As against these theories are the possibilities of improvements in the methods which may permit us to maintain a foundation of six-inch depth and one that will meet the test of heavy traffic.

Any new proposition, involving other than minor changes in specifications, adds to capital expenditure per square yard. A mere increase of two inches in depth of 1:3:6 concrete on a city street, twenty-six feet in width between curbs will, at a conservative estimate, add $10,000 per mile to the initial cost. Would a portion of this added cost utilized for new mechanical methods in the placement of base achieve the results we are looking for at less cost? Recently, the City of Philadelphia contracted for base paving of standard 1:3:6 mix, including a special mechanically applied surface treatment, producing an indented face for an asphalt wearing surface. In addition to ridging or corrugating the surface of the concrete, the method employed apparently "squeezed out" the excess water in the carrying vehicle. A 3½-inch square by 7-inch prism of this concrete was sent to the laboratory and substantiated the claim of a strengthening increment, incidental to the process, by developing a unit compressive strength of 2,430 pounds, 62 per cent over the usually accepted figure of 1,500 pounds per square inch for this mix. We are not selling this idea; the thought merely occurs that this field of research is still open.

Have we secured the best results with only the means at our command? Would the increased cost of additional depth of concrete, or stronger mix, or reinforcement, be absorbed or approached by greater care exercised in preliminary preparation, more rigid adherence to specifications, the reduction to a minimum of the vagaries of human judgment, less speed and better quality in the making and placing of six-inch base? The same elements of uncertainty may and probably will exist no matter what new type of construction is advocated and used, whereas conscientious effort and a betterment in methods, both in construction and maintenance, may be the measure of the most efficient kind of production at less extra cost and without radical changes.

The problem deserves and will receive, no doubt, serious study. If and when changes in type of construction become a part of standard specifications, it would seem that the exercise of good judgment will be essential and necessary as special conditions arise or when, in the opinion of the Engineer, present and anticipated traffic demands are not a part of the consideration of initial costs.

On the other hand we face abnormal conditions in modern transportation, and no one can foresee where the limitations of weight, volume and speed will end. The idea of first cost must be left out of the picture, and we will perforce accept necessary changes in design and construction—build for the factor of resistance upon the same principles as in bridge work and as economically as we may. The end will justify the means.

P. S. Compiled data quoted in this paper are subject to correction due to possible recent changes in specifications.

(Record will be continued in April issue)

The Business Situation

A YEAR ago business was in a somewhat more satisfactory position than it is today. At present there are more indications of reaction or readjustment than there were at this date in 1926.

R. G. Dun's Review calls attention to the fact that production in the textile industry is increasing and in February had reached a record high level. In some other classes there is a seasonable increase although the reports of lessened factory employment are not lacking.

"Viewed broadly, the commercial situation presents many contrasts and some unsatisfactory features, but there has been a distinct improvement in a number of basic lines and the sentiment is conservatively optimistic."

The Cleveland Trust Company Bulletin, edited by Colonel Leonard P. Ayres, is always safely optimistic. It reads, "February is normally the slowest business month of the year, and if that turns out to be true of 1927, this year will be a relatively prosperous one, for business was fairly good last month, and has been improving so far in March. At the present time the favorable symptoms are more numerous and more impressive than the unfavorable ones. The most important adverse developments appear to be the continued slowing down in building construction, some increase in unemployment, and a larger number of business insolvencies. Perhaps the recent considerable declines in the general price level ought to be added to this list.

"On the favorable side the list is longer, and the items more important. Automobile output is increasing rapidly, despite keen competition and some price cutting, and the demand from retail buyers is rapidly approaching the figures of last year and the year before. The textile industries are more active than they have been for a long time. The iron and steel industry is steadily increasing its output, despite some price declines, and its volume of forward orders is swelling.

"Early in March the rate of steel mill activity averaged about 86 per cent of full capacity, with the line still curving upward. The improvement is due to better railroad buying, increasing production by the automobile industry, greater demand from the oil fields, and good buying for miscellaneous manufacturing.

"Traffic on the railroads continues to exceed the figures of last year, and is growing. The consumption of copper is increasing. Agricultural conditions are not good, but the outlook for the cattle business is most promising, and prospective profits should considerably help out farm incomes.

"The business of the tire manufacturers is probably the most prosperous among all the important industries. The production and sale of gasoline and of pneumatic tires go steadily forward year by year, whether general business is good or bad, and without much direct relationship to the actual production of new automobiles. These two great industries are now almost independent of changes in business cycles.

"The present prospects are that business will continue to be good in the months directly ahead."

Goodbody & Co., in their circular of March 10th, say: "We have to thank the conservatism of our business leaders that we have not had a period of inflation and wild speculation in the last few years. As a result of this conservatism we are now in a better situation as to the relation of productive capacity to consumption and as to inventories than we have ever been before at the close of a period of business activity such as the one just past. We are not in danger of a collapse in prices and in business activity which will result in bread lines and red figure income accounts.

"Since business men have not needed surplus funds to fulfill ambitious expansion programs, these funds have turned to building construction for residential purposes and to speculation in real estate and in the stock market. The building operations have been a substantial factor in keeping labor fully employed and in consuming the products of our industries. We have reached a point in building operations, and in city and suburban real estate speculation, where a halt must soon be called. Perhaps this will result in further speculative activity in the securities market as the only remaining field for such operations on this side of the Atlantic. If so, any strength in the market will have to be developed in the face of earnings which will not justify present prices for most speculative securities. In regard to investment issues the outlook for lower interest rates affords reasonable assurance of stability of market price under unfavorable market conditions, and of advancing prices under favorable conditions."

C. E. B.

Air Mileage More Than Doubled

Mileage operated on the air mail routes in the United States increased 126 per cent during the six months ended December 31, 1926, as compared to the corresponding period in 1925. Statistics on the number of letters carried on all routes are not available, but 11 per cent more letters were carried on the Government-operated routes, the transcontinental and the New York-Chicago overnight.

For the six months ended December 31, 1926, the number of miles flown and the number of letters carried on the transcontinental route were fewer than during the same period of 1925, but the mileage flown on the New York-Chicago overnight route increased almost 74,000 miles and the number of letters carried increased 75 per cent.

Taxis for the Air

Air Taxis, Ltd., has just been registered as a private company in England with a capital of £5,000, to carry on business as "Letters-out" on hire of flying machines to carry passengers and goods by air. Mr. W. H. Hope, Managing Director, states that fares will be conveyed anywhere in Europe and Asia at charges of from 40 to 50 cents a mile at a great saving in time compared to road transport.

Captain Hope has given some of his own experiences as a taxi pilot in illustrating the possibilities of air transport for passengers and goods.

"Recently I took a Birmingham business man over 3,000 miles in five days," he said, "in a little two-seater airplane. We flew to the borders of Russia, via Holland, Germany, Belgium, France and back again. There was not a hitch in the whole flight. My fare did his business in a number of towns and cities and when we landed in Birmingham I was duly paid at the rate of 1s, 8d. per mile. There would have been far more fuss and arrangement over a long journey by road in England itself.

"We consider that there is great scope for the venture we have started. This is a day of safe flying, providing there are reliable machines and pilots."

Registration of Professional Engineers in Pennsylvania

An act passed May 25, 1921, for the regulation of the practice of the profession of engineering and of land surveying in Pennsylvania, has been declared unconstitutional by the Supreme Court of the State, but the Court indicated the manner in which the law could be corrected. At the request, and with the co-operation of State Officials, a new bill has been prepared which meets the objections raised by the Supreme Court and has been introduced in the House of Representatives as House Bill No. 915.

A second international Conference on Bituminous Coal will be held at the Carnegie Institute of Technology in November of 1928.

"We are so greatly encouraged by the success of the first International Conference on Bituminous Coal held at the Carnegie Institute of Technology last year," President Baker states, "that we have definitely decided to hold a second and similar international congress two years from now."

The first conference was called for the purpose of finding new uses for bituminous coal and especially to discuss the problem of liquefying coal to supplement the petroleum oil supply of the world. More than 1,700 delegates, including representatives of thirteen different countries, attended.

President Baker stated that the second conference will be planned to uncover whatever new information is made available during the coming two years regarding various problems in the use of soft coal.

Fulweiler Company announce the opening of their new offices at 1700 Walnut street, under the direction of Mr. J. E. Fulweiler, who is well known from his long connection as vice-president of the W. P. Mackenzie Company.

A very practical appreciation of Mr. Fulweiler's past efforts is evidenced by the fact that several of the manufacturers who have been represented by him under his former connections have transferred their accounts to the Fulweiler Company.

Therefore, the customers of The Norwalk Company, The Bundy Steam Trap Company, and the Conveyors Corporation of America will continue to be cared for by Mr. Fulweiler and need only note the new address.

NEW BOOKS

BOOK REVIEWS

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ENGINEERS AND ENGINEERING.
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Personnel Administration, Its Principles and Practice —Tead & Metcalf. Second Edition. 540 pages. 6x9. Illustrated. $5.00.

A thorough revision of the standard work on the principles and practice of the administration of human relations in industry. The book is a practical manual for the head of the personnel department as well as for the executives directly in charge of such matters as employment, health and safety, educational department, joint relations with employees, etc. It is a concrete, forceful and specific answer for practical men to the question: What can be done about the labor problem? In this revision the scope of the book has been widened in order to make it more useful to department store and office personnel workers as well as to those in industrial plants.

British Standard Glossary of Terms Used in Electrical Engineering—Publication No. 205-1926. British Engineering Standards Assoc. $2.00.

The first authoritative list of electrical terms and definitions issued. Commenced in 1908 by the Institution of Electrical Engineers, this work has been taken over and completed by the British Engineering Standards Association with the co-operation of many well-known Electrical Engineers.

Electric Transients—By Carl Edward Magnusson, Professor of Electrical Engineering and Director, Engineering Experiment Station, University of Washington. Second Edition, revised and enlarged. 237 pages, 6x9, 216 illustrations. $3.00.

Dean Magnusson says that since transient electric phenomena generally increase in commercial importance with the size and complexity of electric systems, "a knowledge of the fundamental principles of electric transients and their application to the solution of quantitative problems is as essential to the successful operation of large power and communication systems as a mastery of the basic laws of direct and alternating currents."

A distinctive feature of the book lies in the illustrations. These consist of a large number of oscillograms of transients that occur in the various types of machines and electric circuits in common use in electrical engineering laboratories.

Power-Factor Wastes—By Charles R. Underhill, Consulting Electrical Engineer. 326 pages, 6x9, illustrated. $3.50.

This book tells the user of electric power the facts about power-factor wastes, how much they cost him, as reflected in actual saving, their causes and cures, as proved by experience, and the opinions of a number of authorities in regard to this very important element in production and overhead costs—power.

For the producer of electric power, the book will serve as a convenient gathering of authoritative information on the subject.

The book analyzes the use of electric power in relation to the work it is supposed to do and the work it actually does, and explains the methods which have proved successful in reducing the obvious wastes and losses.

The Standard Handbook for Electrical Engineers—Editor-in-Chief, Frank F. Fowle. Fifth Edition. 25 thumb-indexed sections, 2139 pages, 4x7, flexible, illustrated. $6.00.

A handbook that is really an encyclopedia of electrical engineering. Contributed by over sixty of the leading electrical engineers of America.

Alternating Currents and Transients—By F. M. Colebrook, Assistant in the Wireless Division, National Physical Library, Middlesex, England. 195 pages, 6x9, 96 figures. $3.00.

The method considered is that which has hitherto been variously described as the "Symbolic Method," "Complex Algebra," or the "Rotating-vector Method."

In the first part of the book this method is developed on the basis of the simplest possible definitions of the quantities involved, its essentially vectorial character is elucidated, and, in addition, certain fundamental propositions are established by means of which the range of the applicability of the method is extended so as to include the analysis of transient alternating phenomena.

The remainder of the book is devoted to the practice of the method, illustrated by application to certain typical branches of electrical theory. The treatment of such typical subjects is not intended to be detailed or complete. They are presented in outline only, in order that the application of the method may be illustrated over as wide a range as possible without obscuring the main object of the book by excess of detail.

Applied X-Rays—By George L. Clark, Assistant Professor of Applied Chemical Research, Massachusetts Institute of Technology. 255 pages, 6x9; 99 illustrations. $4.00.

A book that tells what X-rays are, how they may be used, what results they produce, why they can be applied to practical problems of everyday life and how industry is beginning to use them.

Handbook of Non-Ferrous Metallurgy — Editor-in-Chief, Donald M. Liddell, Consulting Engineer. Two volumes, 1440 pages, fully illustrated. $12.00.

An authoritative engineering handbook of the essential professional reference data of non-ferrous metallurgy. Those operations, apparatus and methods which are fundamental to all branches of non-ferrous metallurgy receive first treatment and this section of the book is followed by separate chapters on the metallurgy of the individual metals. Each chapter is the work of one or more specialists.

The book aims to present the kind of practical information the practicing metallurgist wants.

Petroleum Production Engineering—By Lester C. Uren, Associate Professor of Petroleum Engineering, University of California. 657 pages. 6x9. 348 illustrations. $6.00.

The book is valuable as a useful reference work for petroleum engineers, geologists, oil company executives and others requiring an intimate understanding of the producing side of the oil industry. A complete description of the technical aspects of the oil producing industry. Every phase of oil production from the work of the prospector in the location of petroleum deposits to the transportation of crude to the refinery, is described in detail. Every process and method of any consequence is fully explained and complete descriptions are given with illustrations of all commonly used oil field equipment, tools and appliances. In assembling this book, an effort has been made to develop a well-balanced text that does not unduly stress some topics nor slight others. It has been prepared particularly for those seeking a broad view of the entire oil producing industry, and yet there is sufficient detail to provide a thorough-going treatment of the principles, methods and equipment involved.

Fuels and Their Combustion—By Robert T. Haslam and Robert P. Russell. 807 pages, 6x9, 304 illustrations. $7.50.

Since efficiency in combustion and fuel utilization is daily assuming added importance, this book is of prime interest to industrial chemists, industrial executives and mechanical engineers. It covers the field broadly and points out the underlying principles on which further progress must be based.

This is a thorough treatment of the origin, composition and production of fuels and their efficient utilization. The book presents the underlying principles of the science of combustion, describes typical combustion equipment, gives actual plant data, explains common combustion reaction and discusses the flow of air and flue gases and heat transfer. It gives special attention to such topics as producer gas, water gas, oil and coal gas and to gas manufacture and the coking of coal.

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AGRICULTURAL ENGINEER, $3,800 a year, associate agricultural engineer $3,000 and assistant agricultural engineer $2,400 a year. Duties relate to uses, design and operation of farm machinery. Applications may be had from U. S. Civil Service Comm., Washington, D. C.

PETROLEUM ENGINEER, $3,800 a year, natural gas eng., $3,800 a year, associate pet. eng. $3,000, assoc. nat. gas eng., $3,000, assist. pet. eng. $2,400, asst. nat. gas eng. $2,400 a year. Applications may be had from U. S. Civil Service Com., Washington, D. C.

PRINCIPAL TOPOGRAPHIC DRAFTSMAN, $2,100 a year. Top. Draftsman $1,680. Asst. Top. Draftsman $1,500. Junior Top. Draftsman, $1,320 a year. Applications may be had from U. S. Civil Service Com., Washington, D. C.

ENGINEER required with experience on electrical heating especially as applied to electric furnaces. Must be able to make working drawings. Excellent opportunity for capable willing man. State qualifications, age, salary required. Location Philadelphia. Box E-1358.

MECHANICAL DRAFTSMAN with experience in high pressure valve and steam specialty design. Location is in downtown Philadelphia. Please state education and experience chronologically; also salary expected. Address Box E-1359.

SALES ENGINEER, experienced in foundry equipment, particularly in sand blast, and the collection of all kinds of dust, using screen type arresters. Must willingly travel three-fourths of the time, Eastern Penna. and New Jersey. American Foundry & Equipment Co., Mishawaka, Ind.

MEN AVAILABLE:

MECHANICAL AND ELEC. EXP. Graduate of Baltimore Polytechnic Inst. in general Eng. Course, just back in town desires work in Phila. territory. Excellent record in various work can be shown. Age 47. Ref. given. Box A-855.

PLANT OR PRODUCTION ENGINEER with practical experience, also sales experience, well recommended, desires either plant or sales work. Box A-858.

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ELECTRICAL ENGINEER, M. I. T. graduate, with four years' experience in the electrical industry and teaching; desires position of a sales or analytical nature. Box A-862.

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CIVIL ENGINEER. Age 35, graduate. Desires construction valuation and appraisal or sales work. Thoroughly experienced in reinforced concrete construction. Would work with American Company in Europe or South Africa. A-864.

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SALES ENGINEER—5 years' experience, selling, Engineers, Architects, Contractors, Jobbers, etc. Graduate Mechanical Engineer. Age 28. Box A-870.

JUNIOR ELECTRICAL ENGINEER, Age 24, with experience in station Elect. constr., and switchboard wiring, desires position in switchboard design or electrical design dept. Box A-871.

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EXECUTIVE or assistant to a senior executive available immediately. Executive engineer, age 37, with management experience. Good organizer and can get results. A-875.

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ELECTRICAL ENGINEER, part time work, design of industrial and utility, high and low tension installations. Experienced also as superintendent of construction, chief draftsman, purchasing engineer and specification writer. Box A-877.

GRADUATE CIVIL ENGINEER desires evening work at home, computing, drafting or estimating, experienced in property survey, sewer and hydraulic work and some structural steel work. Box A-878.

GRADUATE CIVIL ENGINEER. 9 years' varied construction experience and supervision of erection, also designing, hydraulic work, valuation and estimating. Available for responsible position with construction company. Box A-879.

MECHANICAL DRAFTSMAN with automatic machine design, punch and die and jig and fixture experience, desires position in similar lines. Box A-881.

ELECTRICAL ENGINEERING graduate desires position as assistant construction engineer or equivalent. Ten years' experience elec. construction. Two years elec. design and layout. Age 31, single. Will consider travelling position. Box A-882.

MECHANICAL ENGINEER, graduate Lehigh Univ. over 14 years' thorough combustion and plant experience, field, shop, sales engineer and executive combustion and power equipment, desires change where initiative, ideas, experience and hard work make their own opportunities. Box A-883.

MECHANICAL DRAFTSMAN, Age 20, over 3 years experience on machinery layout and tracing, desires position. Would also accept position as Junior draftsman in architect's office. Box A-884.

GRADUATE ENGINEER, desires position as assistant to advertising or sales manager. Adept in handling correspondence. Box A-885.

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MECHANICAL ENGINEER, A. S. M. E., 27, single, 6 years experience in industrial plants as, Test, Maintenance and Combustion Engineer. Desires position in same capacity, or as Efficiency, or Power Plant Engineer. Box A-888.

ENGINEERS & ENGINEERING

APRIL, 1927

Vol. XLIV FOUNDED 1879 No. 4

The Brunler Flame and Its Industrial Applications

REFERENCE was made in our January 1927 issue* to the Brunler Flame and the difficulties encountered in developing this invention. The first experiments were made by Brunler senior in 1887, in Springfield, Mass., U. S. A., and after 24 years of struggle with technical difficulties he succeeded in making a flame burn under water in a satisfactory manner.

The following description explains the operation of the boiler: The fuel used may be residue oil, producer gas, water-gas, blast-furnace, coke-oven or town-gas, or powdered fuel. In operating the boiler combustion is started by means of a pilot lamp. Fuel and the combustion air are supplied to the pilot lamp and to the main burner under a pressure which exceeds slightly the boiler pressure. Before starting, the water level in the steam generator is lowered below the lower outlet of the burner. The cover of the pilot lamp is removed and the fire-clay lining in the pilot lamp is heated up to red heat. The valves of the pilot lamp are opened and the combustible mixture of fuel and air ignites on the red-hot fireclay. Then the cover is pulled down again and the flame of the pilot lamp makes its way to the main burner. The main regulating valve is then opened and the flame burns in the steam generator. As soon as the main flame burns on the surface of the water in the generator, the liquid is allowed to rise up to the middle of the burner and the flame then burns in the water.

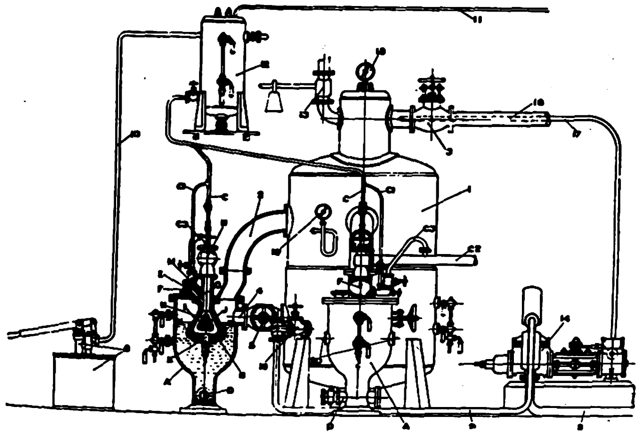

Figure 1.

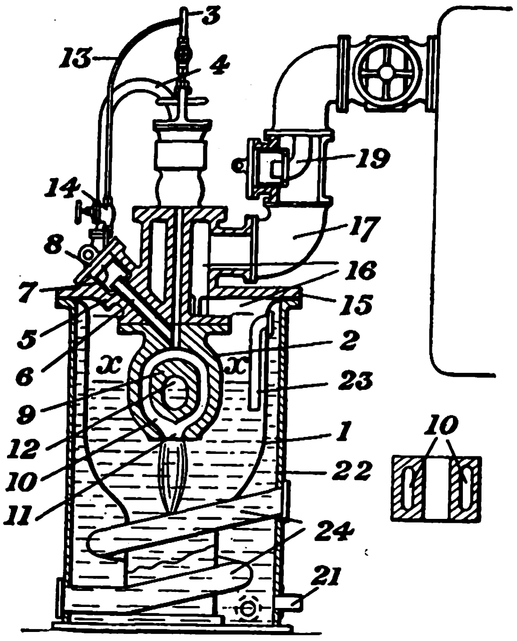

Figure 2.

1, STEAM GENERATOR BODY; 2, BURNER; 3, OIL PIPE; 4, AIR PIPE; 5, STEAM GENERATOR COVER; 6, FIRE-CLAY IN PILOT LAMP; 8, COVER OF PILOT LAMP; 9, BRIDGE PIECE; 10, PASSAGES THROUGH BURNER; 11, BURNER OUTLET; 12, COOLING PASSAGE; 13, OIL PIPE TO PILOT LAMP; 14, STOP VALVE; 15, COVER OF STEAM GENERATOR; 16, STEAM PASSAGE; 17, STEAM PIPE; 19, SUPERHEATER; 21, FEED-WATER INLET; 22, OUTER CASING; 23, FEED WATER DISCHARGE; 24, PREHEATER COIL.

A general arrangement of the plant for power purposes is shown in Fig. 1 while Fig. 2 shows a section through the steam generator. A steam generator 3 feet in diameter and 4 foot 8 inches in height can produce 11,000 lbs. of steam-gas per hour. A steam generator of this type has now been in operation for over 1,800 working hours without any mishap.

By means of a superheater designed on the same principle as the pilot lamp, and the flame of which burns in the steam reservoir or in the steam pipe, the steam can be super-heated to any required degree.

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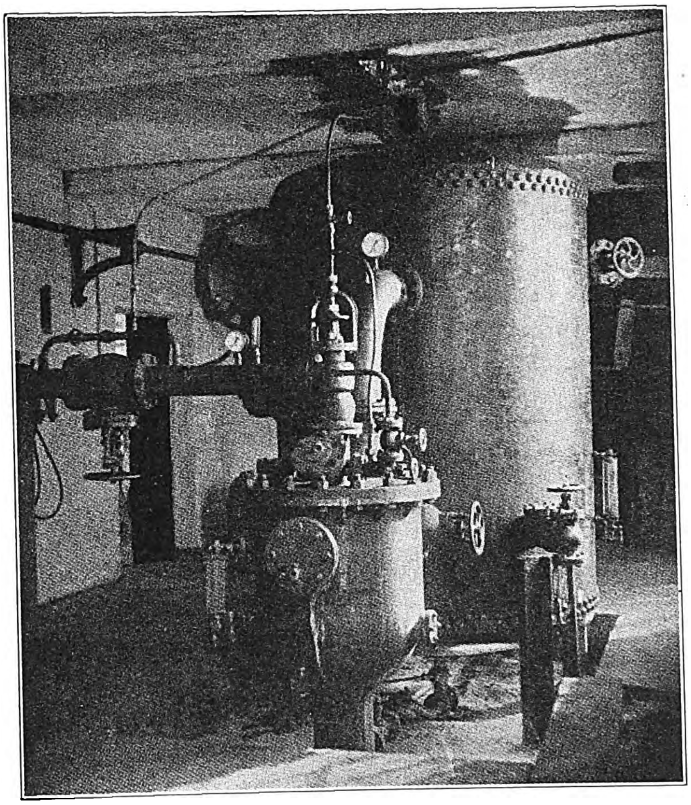
*Page 8.



Experiments to investigate the commercial utility of the Brunler flame for concentrating liquors, manufacture of calcium nitrate, dehydration of peat, sewage sludge, and the like, have been carried out with very satisfactory results. In the following test results are given:

Concentration of Sulphite Pulp Liquor

It is well known that a large percentage of the wood used for the manufacture of paper is lost in the waste liquor. If it were possible to recover the pulp from the waste liquor, a large saving would be effected, and pollution of rivers and streams avoided. Experiments carried out with sulphite-pulp liquor have shown that it is a paying proposition to concentrate the waste liquor and to gasify the concentrate. The following figures give the results of experiments:

Initial temperature of sulphite-pulp liquor, 100°C; initial water content of liquor 90 per cent; final water content 20 per cent. The fuel used was tar oil of 9,000 calories per kilo (16,400 B. T. U.'s per lb.) and the quantity of oil used per 1 ton of liquor, about 120 lbs. (119.6 lbs.). The total quantity of steam-gas produced in concentrating one ton of waste liquor, from 90 to 20 per cent water content, was 4,295 lbs. Surplus power of 74 H. P. was obtained from the steam-gas mixture per ton of liquor.

The concentrate itself, with 20 per cent water content had a calorific value of 7,270 B. T. U.'s per lb., and as one ton of waste liquor gave 265 lbs. of concentrate, the total heat value recovered from one ton of waste liquor was about [265 x 7,270] = 1,920,000 B. T. U.'s. The heat required to concentrate the liquor was 1,968,000 B, T, U.'s and 1,920,000 B. T. U.'s plus 74 H. P. were recovered. The 74 H. P. in excess were obtained in using the steam-gas produced during the concentration process for driving the steam engine and compressor.

In the process, instead of using oil for the flame, the concentrate, which is as solid as charcoal, can be gasified and the gas used for the concentration process.

Sewage Sludge.

Many large towns have great difficulty in disposing of the enormous quantities of sewage, and the disposal of sewage sludge is a matter of great importance. As a rule sewage sludge contains 98 to 99 per cent of water and the following figures may give an idea of the large quantities of sewage, which are produced daily and which have to be disposed of in one way or another. One million gallons of sewage is produced per day from a population of 35,000 people, or the sewerage works of a town of one million inhabitants has to dispose of 30 million gallons of sewage daily. In order to dispose of these enormous quantities various methods and processes have been introduced to dehydrate the sewage. All these processes, however, require a certain time, from 3 to 14 days. Consequently a large area is required to store the sewage until it is dehydrated to about 65 per cent water content.

The experiments which have been recently carried out in using the Brunler flame for the dehydration of the sludge have proved that the latter can be dehydrated, by means of the flame, from 98 per cent to about 60 per cent water content, in which condition it is solid enough to be carted away, and is hard enough to be shoveled.

The following figures give a brief outline of what can be gained in dehydrating the sewage sludge with the Brunler flame.

It has been found that 14 lbs. of water can be evaporated from the sludge with 1 lb. of tar oil of 16,900 B. T. U.'s per lb. In order to reduce the water content of the sludge from 98 to 60 per cent 2,090 lbs. of water must be evaporated from each ton of sewage. This quantity was evaporated with 150 lbs. of oil, and 4,700 lbs. of steam-gas was produced, which, if used in an engine would give approximately 350 H. P. Deducting the power used for the combustion air, which amounts, at 173 lbs. per square inch pressure, to 161 H. P. leaves a net power of 189 H. P.

The results which have been obtained show that sewage sludge can be dehydrated advantageously on a commercial scale, and that the advantages obtained in concentrating the sludge under pressure and using the steam-gas for power production are considerable. Also the dehydrated sludge can be gasified, and the gas produced can be used as fuel for the flame.

The experiments in this direction have not yet been completed, but the results obtained so far are most satisfactory and encouraging. The application of the Brunler flame in this field may overcome many present difficulties as regards sewage disposal.

Concentration of Zinc Chloride

The concentration of zinc chloride, which causes many difficulties in present evaporation plants, has been accomplished on a commercial scale by means of the Brunler flame. The liquor was fed into the boiler at a temperature of 10° Centigrade and 20° Beaumé. The flame burning in the solution concentrated it to 73° Beaumé. After the concentration the steam generator was taken apart to investigate if any corrosion had taken place. Corrosion had not occurred, but it was found that the walls of the steam generator were coated with a fine layer of zinc. Further tests carried out with the same solution showed the same results. The zinc coating in the steam generator can only be explained by the electro-ionic theory.

The electro-ionic theory and practical results have shown that under certain conditions the Brunler flame produces effects which can only be explained by the interatonic theory. A vast amount of research has been carried out in this direction and the results obtained may lead to entirely new conceptions of the calorific value of fuels. O. B.

Our Relations With Our Latin-American Neighbors*

By PROFESSOR H. T. COLLINGS

Professor of Economics, Wharton School, University of Pennsylvania

I SHALL speak briefly on two points. Who are the Latin-Americans is the first, and the second, what special relations have we with Mexico and Nicaragua at the present time? Since I teach International Trade and the Latin-American classes at the Wharton School, I have felt that it was my business on numerous occasions to visit South America, Central America, or Mexico, to get a first hand knowledge of these people, and consequently, I will try to speak from the first hand information I have gleaned from time to time, with a view to giving a background. I could talk for the half hour on Mexico and Nicaragua and the present situation, but it would be to my mind like an engineer who started to construct a bridge and never considered anything below the surface of the water. I believe your main concern is the foundation, so I will attempt to portray a background which will do more to help you draw your own conclusions than any fact I might bring to you.

Let me turn to the topic, then, "Who are our Latin-American neighbors?" In the first place, there are two Americas, but not North and South America. That is a mere geographical distinction that has no particular significance. There is, however, an America known as Latin-America. There is another (to which we belong)—Anglo-Saxon America, and they are radically different. In the first place, these Latin-American neighbors, our friends to the south of the Rio Grande in twenty republics of Mexico, Central America and South America, speak an entirely different language, Spanish, in each case, except in Brazil, where Portuguese is the language, and in Haiti, where French, or a patois of French is the language spoken.

For 300 years, these peoples were members of colonies belonging to Spain or Portugal, and during those 300 years, they had experiences entirely different from our own. For example, Spain restricted the commercial and political life of these peoples in every conceivable way. The colonies were largely exploited for the benefit of the mother countries. Gold, and especially silver, were taken from these colonies to benefit Spain and Portugal. They were governed entirely from the mother country, by representatives sent from that area. The entire territory was to be handled for the benefit of the mother country, and not for the colonies. Therefore, for three hundred years of government experience, they had no practice whatever in handling their own problems. If you contrast with that the experience of our colonists, you will find that we had a radically different background in which to work in the 19th and 20th centuries. Latin-American governments which have been weak and vacillating in the last decade or two may be explained then, partly, and perhaps excused, on the ground that they are getting their first experience in real governmental control. To be sure, these colonies have been independent for one hundred years, but even during the past hundred years they have been largely under the control of tyrants, or rulers, who gave the people little actual participation in the government.

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*Address before the Engineers Club, March 8, 1927.

Let me turn to the society in the Latin-American group. One finds an entirely different social situation from that found in our country. For example, there is no color line in Latin-America. That a certain man has Indian blood in his veins, or even colored blood, does not necessarily militate against him in social circles. In Brazil, for example, where colored blood is common, a man is counted as white until he is entirely black, reversing exactly our attitude toward the situation. That a man in Mexico should have Indian blood is something of which he may be proud, for their most distinguished President was a full-blooded Indian.

One finds, then, an entirely different social situation with reference to the Latin-American republics; many practices that are entirely different from our own. They help to explain the attitude of those peoples toward foreigners. For example, the matter of courtesy. Every Latin-American is by nature courteous. It may be external, to be sure, but it is a part of his make-up. He says, "How do you do?" and he expects an answer. It is no longer a question with us; it is a greeting. But he expects to tell you how he does, and his aunt and his grandmother, and his mother and all the rest, and he expects you to listen. Every peon, the common working class of Latin-America, expects to show extreme courtesy to all those with whom he comes in contact, especially if they are his superiors. On a good many occasions, I have gone through manufacturing plants in Latin-America with the President of the Board of Directors, and every time a workman came near us, he took off his hat; on one or two occasions, they have even kneeled as we passed by. Contrast with that the attitude of the American workman who, when he sees the boss coming says, "Cheese it! The big guy!" and ducks for cover.

I am trying to point out some respects in which these peoples differ radically from ourselves, in order that you may get the background which will help you to understand their appreciation of problems and their attitude towards them.

I should say in general that the Latin-American is less mutually trustful than we are. These peoples seem by nature to be suspicious of each other, much more so than we Anglo-Saxons. They are a supersensitive people. All peoples are supersensitive, but these seem to be especially so. Consequently, the least reason for suspicion in their mind is magnified to an extent that makes a mountain out of a molehill. They seem to be good beginners, and not such good finishers. There is less shame at quitting in Latin-America than there seems to be in the United States. To begin a job and to leave it before we have finished is the greatest disgrace for Anglo-Saxons. Not quite so much so for our Latin-American friends. I remember the Chinese student who advertised in Pekin that he taught the English language up to the letter G. I don't know just what he meant, but it has struck me that that describes in many ways the Latin-American's attitude toward a problem.

In religion, these people are 99% Roman Catholic. Therefore, they approach religion from an entirely different background than our own. Religion is in many cases there a formal matter, much more in the attention of the women than the men, and yet it sometimes permeates Latin-American life much more thoroughly than it does our own.

One other matter; let me turn to the business side. In business, these people have an entirely different attitude toward life. Their appreciation of manual labor is entirely different from our own. From the days of Spain and from Plato they have inherited a dislike for manual labor. It is undesirable to be a manual laborer, or to do jobs that verge on the manual, and consequently, one finds an entirely different attitude toward the business of life in Latin-America from that which he finds in the United States. The workman who carries a bundle in the street thereby classes himself in a certain social stratum. It would not be possible for me or you to do that sort of thing.

They are not impressed by efficiency. Should I persuade an American that the machine which I sell him will produce eleven products per hour instead of seven, which the machine on his floor now produces, I have "sold" him, to use the American phrase. But in Buenos Aires, on one occasion I persuaded a manufacturer just that, and he came back with the pertinent and impertinent question, "What would I do with the other four products." That attitude toward business is so entirely different from our own that we must realize it to see how they look at the situation.

So I could continue. The Latin-American finds in his bsuiness life that he is largely subject to foreign investments, and to a certain extent to foreign control. Naturally, he believes that the foreigner is exploiting his country for the foreigner's benefit. It may not be true; it is not true, in a large number of instances, and yet, the background for the Latin-American is such that he approaches life from an entirely different point of view and his judgments are therefore many times diverse from our own.

Let me turn briefly to the second topic, the present situation in Mexico and Nicaragua. The present situation in Mexico arises from the Constitution of 1917. In that Constitution, Article 27 declared that sub-soil properties belong to the Mexican Government. That is to say, the owner of the surface is not thereby the owner of sub-soil properties, such as oil and minerals. Now, under Anglo-Saxon law, the owner of the surface owns to the center of the earth. In Spain, however, there was for many centuries, a law that the King and Queen owned all except the surface, which was owned by the so-called proprietor. If we accept that attitude toward ownership, then Mexico has not brought out something new in this Constitution, but has merely gone back to old Spanish law and claimed that the owner of the surface is not the owner of the sub-soil properties, oil and minerals.

In 1917, the new constitution in its Article 27 made that declaration. Our Secretary, Mr. Hughes, in June, 1921, carried on a contention for us. Mexico might make such a law if she saw fit, but it was undesirable to do so. However, we could not object on that point. Mr. Hughes' contention was that such an arrangement should not be retroactive, that it was not defensible under International Law, to make the application to oil companies, mining companies, and others, which had leased, or bought property, under the laws of Mexico previous to 1917. That was his only contention, that we may have such a law as Mexico makes in Article 27, but it must not be retroactive. Article 14 of the Constitution of 1917 states that "Nothing in this Constitution shall be retroactive," but certain procedures since 1917, and especially since January, 1927, have led us to believe that retroactivity is a part of this Article 27. For three years, 1920 to 1923, the President of Mexico, Señor Obregón, was not recognized by the United States because of this difference of interpretation. In the summer of 1923, two commissioners, Warren and Payne, from the United States, made an arrangement which we regarded as temporary, but satisfactory for the recognition of Obregón and the Mexican regime. This was a boon to Mexico because it created a credit standing that she could not otherwise have. Under the President of Mexico at the present time, Señor Calles, there seems to be a return to the other doctrine of retroactivity under Article 27, and the difficulty which has now arisen between the United States and Mexico centers on whether or not this Article 27 is to be applied retroactively to mining property and oil holdings of the United States and other nations.

There is one other difficulty in Mexico at the present time which does not concern us particularly because it is largely a domestic matter. The President has endeavored to separate Church and State. He maintains that the Catholic Church has been engaging in political matters, and he is endeavoring to separate Church and State, which does not concern us as particularly as Article 27.

President Calles is, of course, himself a Catholic. No one can be President of Mexico, or of any of the other Latin-American republics, unless he is a Roman Catholic; it is required by the Constitution. He says he is not driving the Catholic Church out of his country, but only out of politics.

To turn to Nicaragua. We had in Nicaragua, 100 or more marines from 1912 to 1925. A new President of Nicaragua was elected, President Solorzano, in 1924. His opponent was a certain Chamorro. The new President, Señor Solorzano, took office January 1, 1925, with a Vice-President by the name of Sacasa, who, I believe, was a graduate in medicine of the University of Pennsylvania. Shortly after he took office, the marines of the United States Government left, after thirteen years of partial occupation. Disturbances began at once in Nicaragua between the President and his opponent, Chamorro. The latter gained in power throughout the country, and gradually the Chief Executive lost. To make a long story short, the President finally resigned his office. The natural and proper constitutional procedure would then have been for the Vice-President, Señor Sacasa, to take his place. But the Vice-President had been out of the country for many months, first in the United States, and later in Mexico. Therefore, instead of the Vice-President taking the place of the resigned President, a new election was held in November, 1926. The President, elected by the Congress, with a vote of 45 in his favor and 8 against him, was Señor Adolpho Diaz, whom we have recognized. Our State Department has done that on the principle that we always recognize legally-selected executives in foreign countries. Actual governments elected by the people are those which we recognize, and that has been a principle throughout our diplomatic history. Against this chosen President there arose in power the Vice-President, Sacasa, who returned to the country from Mexico, and he espoused the cause of the opposing party. His regime was recognized by Mexico, and consequently the dispute between Mexico and the United States in the Nicaraguan question has arisen.

Apparently, the situation in Nicaragua has resolved itself into this, that the present President of the country, Señor Diaz, calls upon the United States Government for the support of marines, and a considerable number of them have been sent down there to protect American lives and property. Opposed to that United States group and Señor Diaz, is what our government thinks of as the minority party, at the head of which is the former Vice-President, backed by Mexico.

The Mexican situation seems to be more surely a settled one because of the fact that Mexico, in the course of another year, will have a new President, who evidently is favorable in many respects to a settlement of business questions between his country and the United States that will be fair to both.

On half a dozen occasions, I have gone to Latin-America with a view to finding out situations in which Americans have exploited our Southern neighbors, in which we have done things to hurt them and benefit ourselves. I have never found one important occasion where American business firms in Latin-America were not as fair to our Latin-American neighbors as they are to our own people in their business here. In other words, the Latin-American interests are promoted by our business firms in exactly the same way, and with as much reasonableness, as they are in our own country. I am convinced, too, that our State Department is not looking for occasions for war in Latin-America, but the contrary. It is the difference of background, the Latin-American versus the Anglo-Saxon, that leads to these serious difficulties. I believe that more and more as we come to understand these peoples we will come to appreciate the problems that they have and not misinterpret them. It is easy to see, that when we do not appreciate the Latin-American background, we can misjudge them; vice versa, as they do not appreciate our background, they can misjudge us. I believe that a way is being found by means of acquainting these peoples with each other which will lead to the settlement of all Latin-American problems.

Heat Treatment in Engineering

By R. M. BIRD,
Past President, American Society for Steel Treating

VERY little was known about heat-treatment of steel until ten or fifteen years ago. A few manufacturers thought they knew something about it, but they kept the windows of their plants blackened, and gave out no information. Except in special lines, such as the automobile, there was very little practical, common sense, technical information available. A few college professors had written books on the subject which was about the only literature. Then came the war, and the need for heat treated materials developed a lot of young scientific men who wanted to know the "Why." Afterwards, these men kept on asking "why," thus the barrier of secrecy was pretty well broken down. Eight years ago, there was a consolidation of two little heat treatment organizations, one in Chicago and one in Detroit, which organized the American Society for Steel Treating. This Society has grown tremendously in these few years until today it is recognized by all of the outstanding old line technical organizations.

Heat treating has had an important part in industry. For instance, we speak of metals resisting corrosion, and the development of the chrome steel known as Stainless steel. Heat treatment plays an important part, because without proper heat treatment the material is not stainless. Much has been written on the subject of the preservation of metals from chemical decay by means of various coatings, and I often wonder why it is that we do not hear anything about what has been done, and is being done, to prevent physical decay.

It is hard to realize that only a few years ago a full kit of replacement parts was needed, for an automobile trip of any distance, and breakdowns occurred constantly in the large machinery of mills, transportation lines and elsewhere. Such breakdowns were expected. Today heat treatment has had much to do with the reduction of losses due to "physical decay." The automobile, of course, is the outstanding example of what has been accomplished and what is to be expected.

We are now recognizing a new large field, that of material engineering as a part of the engineering profession, and in that field the knowledge of heat treatment of metals has a large part. Every one is interested, at one time or another, in the selection of a material to do certain work. Material engineering, as I see it, has for its job the manufacture of the finished article, at the lowest possible cost, which will work in service. In order to accomplish that result it takes a combination of all the engineering brains that we have.

"Uncle" John Fritz told me when I was quite a lad, "Bob, there are two kinds of damn-fool engineers. There is the engineer who makes a thing too weak and it breaks, and everybody knows he is a damn-fool. And there is the other fellow who makes a thing too strong. It doesn't break, and nobody knows that he is a fool."

Besides the question of additional expense through making things unnecessarily large, I consider that the second classification includes a lot of other things, such as prejudice, and ultra-conservatism, and all that sort of thing. For example, one of the greatest deterrents, to the betterment of ordinance, particularly metals which will withstand the erosion in gun liners, has been the governmental policy under which no officer of the army or navy gets any credit for any good original thing that he does, but if he does make a bull, he gets demerits. How can it be expected, under that system, that there will be any incentive on the part of government officers to try something new?

In the use of special steel alloys the engineer can and should do a lot of things. We are often blinded by the claims that are made and use some expensive alloy, expecting to get a better product. I believe the trend is toward the use of less of these expensive alloys except when it is definitely known that they will give us the best results. In other words, the material engineer is not going to justify himself by using, for a large steel forging, special steel alloys, such as high nickel-chrome steel which has high mortality all through manufacture—when it has no better physical characteristics than a lower cost alloy (less nickel or chrome or something else), and furthermore is likely to be more treacherous in service than some simpler material. The engineer of the future cannot establish an alibi by saying, "Well, I prescribed the best materials that I knew." No. He will use the knowledge which is gradually being correlated out of all this past mysticism, and match it up, so that he will put in the balance all of the factors, and select that material which he believes in the last analysis is going to do the job at the least possible cost. The study of the characteristics of different steels is a tremendous field. For instance, in automobile structures, there are eighteen different types of steel used for axles and crankshafts. I don't mean eighteen different analyses, but eighteen different kinds of steel, and of those eighteen there are nine, each of which claims to be the best. Nobody knows which of those nine steels, under the different conditions of manufacture and heat treatment, is best, for even a small part such as an automobile crank shaft or an axle. We have to admit we do not know and if that is true, then it is still more true, when we get into complicated structures of which we know less than we think we do.

One of the biggest developments since the war has been the steam turbine and large motor generator units. These have been possible only because people connected with this development have met all the conditions, as they have been able to see them, which would insure safe finished forgings. The danger of breakage, at high speeds, is so great that no banker would think of advancing money to the utility company unless he was mighty sure that the machine after it was started would continue to run. The predominating thing that made for success lies in the fact that the simpler steels were selected and that by proper heat treatment all internal stresses were removed from the forgings. Now as engineers, whether we are designing or fabricating, the predominating mistake that we all make is in having too small fillets. It was my business to inspect broken forgings at a large steel plant for a number of years, and I should say that 95% of the failures in service were due directly to a small fillet or a sharp corner. Now a fillet in a small tool such as a high speed tool, may be practically a nick. In a large gyroscope forging, a fillet of a half inch radius may proportionally represent more of a nick around which stress concentrate than would that minute nick in a small tool; and we can not figure the stresses that develop there.

With the application of available information mistakes can be avoided and the whole industry developed much faster. For instance, manganese steel is recommended for bucket teeth and centrifugal pumps for pumping and mining sand. The sales engineer knows that manganese steel works well in quarries; he does not realize that in operations such as dredging and pumping sand there is no abrasion, no stone, nothing to cold work the metal, and that if manganese steel is not cold worked it will wear as fast as a soft steel.

Now the burden of my song is simply this; that we all recognize the fact that heat treatment in its largest sense has an important part in material engineering. That applies to the nonferrous metals today, coming in strong, as well as to the steels. If this is so, then let us use all available information. The American Society for Steel Treating has a larger amount of authentic literature than has been available heretofore.

Four-Speed Gears Give Better Operation

The great possibilities for improvement in all-round car performance by the use of a suitable four-speed transmission make it probable that a somewhat general tendency in this direction may be expected during the next two or three years, in the opinion of C. A. Neracher and Harold Nutt, of Durant Motors, who described at the recent annual meeting of the Society of Automotive Engineers a new transmission of this type in which internal ring gears instead of spur gears are used for drive in third speed. These are carried in a cylindrical housing at the forward end of the gear box, and drive is direct on fourth speed. The use of internal gears results in a quiet and efficient third gear, it was declared, and careful laboratory tests of the transmission showed a power loss under full load of only 2 per cent through the internal gear. Road tests made on the Long Island Motor Parkway with four-cylinder and six-cylinder cars equipped with the new transmission showed gasoline economies ranging from 14.4 to 20.5 per cent. The maximum savings occur at high car speed. Drive on the third speed gear is almost as quiet as direct drive.

With direct drive on fourth speed the drop in engine speed from third to fourth is 28 per cent, which gives slow engine speed without reducing the ability of the car in direct drive sufficiently to require frequent gear shifting. By proper selection of a fourth speed ratio the engine speed for a given car speed can be reduced from 20 to 30 per cent and thus bring the high car speed close to the maximum engine power and efficiency. More than 90 per cent of normal driving can be done on direct drive in fourth speed if the over-all ratio is rightly selected.

Inside-Frosted Lamps*

A Discovery Promoting Efficient Light Production

GROWING appreciation of the importance of good electric lighting during the decade between 1915 and 1925 led to much wider use of diffused light. Diffusion by enclosing the lamps in translucent glassware and adequate shades and by using other devices was a vague subject to the general public.

Consequently with the advent of the high-efficiency tungsten lamp, the manufacturers endeavored to conceal the bright filaments by etching or frosting the bulbs. Frosting on the outside of the bulb proved objectionable for two chief reasons. It was wasteful of light, offsetting, to a slight degree, the great progress made in increasing the light-producing efficiency of the filament. Also, outside-frosted lamps collected dust and dirt quickly, which could not easily be wiped off.

For many years lamp engineers realized that a lamp frosted on the inside, instead of on the outside, would be very desirable. It would not only present a smooth outside surface and be as easily cleaned as a clear lamp, but a lighter frosting would suffice, increasing the efficiency. The trouble with the idea was, that when a lamp bulb was frosted on the inside, it became as brittle as an egg shell. For twenty years engineers wrestled with this problem to no avail, until Marvin Pipkin solved the difficulty. The method is simple.

A strong solution of acid is first sprayed into the bulb, which etches it. In this condition the surface of the glass is made up of irregular little projections with many sharp angles. While the glass is still in this state it is extremely weak, and a slight pressure or bump is sufficient to shatter it. So far, the process is similar to former attempts at inside frosting. The difference lies in the strengthening process, which is the application of another acid solution, somewhat weaker than the first. This second treating rounds off the sharp edges and minute projections, giving the glass an appearance, under a powerful microscope, of being made up of tiny hemispheres. The bulb is now strong again,—just as strong as it was originally.

Superiority of the inside-frosted lamp over the outside-frosted, so far as light transmitting characteristics are concerned, also needs explanation. In the outside-frosted lamp, light from the filament travels through the gas or vacuum to the wall of the bulb, then through the glass, on the outer surface of which it meets the frost. Then, depending upon the direction of the plane of the particle of rough surfaces, the beam either passes on through the frosted surface as useful light or is reflected back through the glass layer. Each time the light passes through the glass, a certain amount of absorption takes place.

Diffusion of the light by the inside frost is obtained by prismatic refraction with comparatively little loss. In fact, the inside frost allows an even greater portion of the light to pass through than does a similar frost on the outside of the lamp. This is due to the fact that the multiple internal reflections are not so numerous in the inside frosted lamp because the rough, interior surface does not reflect any considerable portion of the light back and forth inside the lamp as happens with the outside-frosted lamps. Moreover, the relative absorption of the inside-frost does not increase so rapidly with the life of the lamps as does that of other diffusing media.

For these reasons, then, the inside-frosted lamp is only about two percent less efficient than a clear lamp, contrasted with a loss of efficiency of three to four times this much in the old style sand-frosted and sprayed lamps.

Another great benefit of the discovery of inside frosting is at once apparent when it is realized that now the manufacturers need only one type of lamp of each wattage instead of lamps with several different finishes. This is beneficial not only from the standpoint of economies resulting from the increased use of automatic machinery and the decreased investment in lamps lying idle in warehouses and on dealers' shelves, but also there is still greater benefit for the public in general. Since the inside-frosted lamps give practically as much light as clear lamps, they can be used to replace clear lamps for every ordinary use. This means that wherever, because of ignorance or carelessness, lamps are used without proper shades or glassware, the inside-frosted lamps will afford a certain degree of eyesight protection. Furthermore, wherever lamps are properly shaded, the inside frosting will eliminate sharp shadows and striations, with negligible loss of efficiency.

The invention of the inside-frosting process, of the same order of importance as the invention of gas-filled lamps and tipless lamp construction, is one more example of the value of systematic research, persistently pursued.

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*Engineering Foundation Research Narrative, No. 117. Contributed by W. M. Skiff, Member A. I. E. E., National Lamp Works, of General Electric Company, Cleveland, Ohio

City Traffic Problems*

By MAJOR RUDOLPH F. KELKER, JR.,

Consulting Engineer, Chicago, Ill.

THE traffic problem is really a matter of engineering interest and not so much of lay interest, for the simple reason that engineers have been taught by training and experience in life to approach matters from a technical point of view. There are very few things in city life that are more complex and more difficult to handle than the traffic problem. The reason for this is that it is constantly changing, never exactly the same, and that is one of the reasons why a great many people make mistakes in trying to arrive at a solution. Engineers know that in a matter of this kind, there can be no definite plan, fixed conclusion or permanent solution, but that there are certain elements of control, in themselves effective and, yet, at the same time elements which may be modified as time goes on or as requirements change. An effective and yet elastic type of regulation, instead of a hard and fast legal regulation, which latter many laymen believe is the proper kind.

The first elements in considering the traffic problem are the general arrangement of streets, and the amount of space that is devoted to the movement of traffic, both pedestrian and vehicular. Next is the way the spaces are used. We know from our experience that if we could secure uniformity of speed we would get a maximum output, but we find great differences in the speed of the various classes of vehicles. The automobile has a high potential speed which it can not use; street cars have a fairly high speed, limited by the time required for loading and unloading: heavy trucks have their own particular speed and, lastly, the pedestrian, whose speed is limited by the obstructions on the sidewalks, at crossings, intersections, etc. So you can figure out 25, 30 or probably 50 elements which enter into the speed problem. In nearly every city the handling of traffic has been turned over completely to the Police Department. This practice has grown up from the days when the officer was first stationed at an intersection to hold up his hand to stop traffic so that pedestrians might go across occasionally but, with the increase in traffic has come the enlargement of the traffic force and changes in traffic laws and regulations. Today, we have a body of men, trained in the physical handling of traffic who, unfortunately, from the nature of their work, are not trained in the technical handling of traffic. The first duty of an officer on the corner is to move the traffic he can see. Obviously, he can't tell what is going on at an adjacent intersection, so he settles his own little problem right then and there without reference to what may be happening elsewhere. That type of control is already becoming a thing of the past, because it cannot get the results we need. Again, we find that a certain group of policemen will give preference at some intersections to street cars, at others to automobiles, and so again, we have an unbalanced regulation and one that lacks uniformity. It is in this phase of the traffic problem that engineering experience and advice is essentially desirable. Then too, those who are in charge of the handling of the Police in all our cities have plenty to do to attend to their own proper job. I have never yet been in a city where the Superintendent or Chief of Police thought he had enough men to do what the Police Department is supposed to do. Consequently something has to suffer and it is almost always the traffic end. We need men who are trained in their business, who have experience and vision to handle and organize real traffic control from the point of view of the human element. To do that, we have to take from our Police force our best, most active and most alert men, and put them on traffic duty, sacrificing necessarily the need of the force in its other important activities.

The other point is that any Superintendent or Chief of Police in a large city has about all he can handle effectively in looking after police work alone, leaving aside traffic matters. If we are to approach the matter from a more technical point of view it is obvious that we must first effect some reasonable organization. We can not hope to cope with the situation of today with the Police organization of yesterday, unless that organization is changed to meet the demands of the present day. One of the best ways to effect the desired change is to continue to leave the control and discipline of the men on the Force under the Chief of Police, and also have a semi-official body made up, for instance, of the members of the Mayor's cabinet, or men of other official position, who will be grouped together as a Traffic Commission, such commission to act as a clearing house on traffic matters and be supplemented by a trained technical staff to gather information and data, to keep informed and in touch constantly with changing conditions throughout the city and to furnish necessary advice to the Commission. Then you will have an organization that cannot help but aid in doing the work. It can make valuable, practical recommendations to the City Council, or whatever the law making body may be, and to the Chief of Police. If you can arrive at that form of a solution, then you can arrange for uniformity in control and at the same time bring about standardization of signals. You would have a technical staff advising your Commission so that it would be well aware of the needs, as well as the best methods to pursue, to achieve the end.

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*Address before the Engineers Club, January 18, 1927.

In nearly all of our large cities, the vast mass of people are moved upon rapid transit trains, or upon street cars. As soon as they are discharged, they become pedestrians and have to have their position in the picture as such, but if we permit one group, by reason of lack of regulation, or imperfect regulation, to monopolize or misuse a part of the very valuable street space, then we are not giving the best and highest service, on either the roadway or the sidewalk. Consequently, in determining the desirability of any regulation, or in endeavoring to obtain an idea as to the method of procedure, we must necessarily consider, and where possible to give the right of way to, the first and most important transportation element using the street, that is, the street car. The street car handles, in Chicago, about 75 percent of our local transportation passengers. However, in the central business district the street cars carry about 60% of all passenger carrying vehicles using the street surfaces. Of the remainder, (exclusive of Motor Buses) 9% is carried by private automobiles and taxi cabs. The average number of passengers, eight-tenths (8/10) per taxi, not including drivers, is entirely disproportionate to both numbers and mileage of this class of transportation.

The most flagrant misuse of valuable street space is the parking of cars. Chicago, a little over ten years ago, passed an ordinance prohibiting the parking of cars on the downtown streets, between the hours of 7 and 10 in the morning and 4 and 6:30 in the evening. The theory was that after about half of Chicago's population had been arrested and properly fined they would learn "to dread the fire." The strange thing is that instead of dreading the fire, as the burned child does, the parker pays a fine and then another and keeps on parking. Chicago averages from 350 to 450 arrests a day for parking. Instead of the people getting wise to the fact that they will be fined for parking, they simply figure, apparently, that its just like paying so much for gas, or oil, or garage rent; they charge it up to parking their car and let it go at that. When they get in that frame of mind there is nothing else to do but prohibit parking because obviously the streets must be given up to moving vehicles. There is no good reason why you and I should be allowed to spot our car in front of some man's house, or store, and let it stand there all day and yet think that we are treating the owner of the property, or the other users of the street fairly. If there were in the busy area of a city enough room to park all the cars that are licensed in the city, so each fellow could have his stall or stand, it would be fair, but it is now a case of the "early bird getting the worm"; the fellow who gets down first gets his place and there he is and you can whistle.

There is more mis-information about parking than anything else in the traffic problem. In the loop district of Chicago, say 7 blocks one way and 9 the other, or nearly half a square mile, there is space at the curbs for 3500 to 3800 cars, after leaving space that must be open for driveways, etc. We have about 350,000 cars registered. Obviously, it is a hundred to one that you will get no place. With this situation, we have a vast volume of important traffic, namely the taxi cab, private auto, and bus that all want to get up to the curb to deliver or take on passengers, and the truck, or the parcel delivery truck, to deliver or collect merchandise. It is just as wrong for the delivery truck to monopolize the curb space for an unreasonable length of time as it is for the parker. If deliveries must be made from the second row it simply chokes up your street until there may be only one lane free for the movement of traffic. Such handling of traffic cuts down the actual use of the width of the street 30 or 50 percent, as the case may be. Philadelphia is particularly unfortunate in having three lane streets, and it is frankly a crime to block everything because you want to get a tooth filled, or something like that. The fairest thing, unquestionably, and the wisest thing, even though probably one of the most disagreeable things, is to consider seriously the cleaning up of the streets by getting rid of both parked cars and the gentleman who thinks it is the city's duty to provide him with free parking space wherever and whenever he sees fit to use it.

We started yesterday (January 17, 1927) in Chicago, on an anti-parking ordinance. We want it because we think it is right. Our great merchants are with us in the matter. We have found that only a fraction of a percent of the people, who come down town to shop, park their cars in the street. When I hear merchants say that they would go into bankruptcy if parking were prohibited, frankly, they don't impress me, because I don't think they know what they are talking about. If they will do what Chicago merchants did at their own expense, make a check of their own patrons and ascertain for themselves just what percent of the people who come to their store and trade every day, park their cars in the city streets, I think they would be surprised. It is a fraction of a percent, with us, and I doubt if it is any greater here.

Due to the huge growth of traffic throughout the country, we are obliged to use mechanical regulation. Each city has picked up some kind of a signal system, either manually or automatically controlled. The result is that most of our signal developments are, more or less, hit or miss. We tackled the signal problem in Chicago a few years ago after we had, to a certain extent, cleared up our loop district. We had been trying to re-route our street cars for a long time. Chicago lies on the west shore of Lake Michigan with plenty of room north and south for through movement of street cars but from the west they come into the loop district, turn and leave again. There were three tracks on State Street, and there was a good deal of over-lapping of car movements and so finally, against the wish and advice and against everything else that the State Street merchants had in mind, the cars were taken off the west track. In other words, they figured that the people from the West Side of the city should be brought to State Street to make their purchases. Some of us thought that if we got them as far as Dearborn Street, one block away, they would walk to State Street, if they had any business there, and so we re-routed West Side street cars, increasing traffic capacity some 15 or 20 percent. We then prohibited in the same area the left hand turning of automobiles and that was a considerable advantage of about the same value. We then considered signalling. The Commissioner of Gas and Electricity got hold of pretty nearly all of the best signals on the market, had them set up in the city yard and turned a lot of trouble shooters, who look after lighting troubles in the city, on these signals and asked them to tell him what they thought was wrong with any of them, if anything. The conclusion was that we had better design our own signal. I think we have, probably, as permanent a signal installation as any city. Our signals have four-way heads and are set on the four corners of every street intersection. They control the traffic at 49 intersections and are all controlled from one large switchboard in the City Hall. We vary the length of the signal intervals by means of a friction drive, the simple turning of a wheel on the switchboard changes the number of seconds of the interval. Each intersection has its own lines that come in to that switchboard and each intersection can be timed differently from any other intersection except that the total signal cycle is the same at all times. That is, if we have 100 seconds for the signal cycle, we can allot sixty seconds red and forty green or fifty-fifty, or twenty-eighty as the case may be, adjusting then the amount of red and green at each intersection according to the needs of that intersection and we can also move the zero at each intersection independently so that if one intersection turns red, the next intersection will turn red, 5, 10, 15 or 20 seconds later, thus at each intersection we have an individual and separate switch control of an adjustable character that fits in with the whole works. That is what we call a co-ordinated system of signals. It is different from that in use in most cities. We can take any particular intersection, for instance State and Madison, or State and Washington, where the east and west traffic is probably 58 and the north and south 42 percent, or further south, at Adams Street, where the east and west traffic is about thirty percent and north and south seventy percent—you are bound to find these variations at all your intersections—and under our method of control we can adjust and time the amount of green, or the number of seconds allowed for cross traffic in either direction, without upsetting or interfering with the timing of the signals at any other of the 49 intersections.

That is an achievement we think is well worth while in signalling in a large city and particularly the central area. The result can be stated in a very few words. It now takes our street cars on State Street, our heaviest artery, to move from Van Buren Street to the River just one-half the time it did before these three things were done—just one-half. That means there are thousands and thousands of people affected beneficially, in the higher speed and, what is still more important, in the reliability of the service that our street car lines can afford. This work was done by the city. The adjustments of time on the signal system were made to fit the movements of our street cars, not because the Chicago Surface Lines asked us to do so, but because we knew, as public servants, our job was to get the best service we could for the greatest number of people.

In Cleveland a stop-and-go system is in use, operated by a man in a tower as he sees the traffic from his particular point of vision. It is an on-and-off system, stop-and-go. The result is, all of the trolley cars are stopping and starting at the same time, creating an unnecessary load on the generators, an unnecessary and wasteful current demand. Now that could be obviated by simply reversing the lights at alternate intersections but, without wishing to speak in uncomplimentary terms of the police department, in Cleveland it is wholly within the jurisdiction of the chief of police. I submit, how can a man accustomed to catching bootleggers and running down bandits be expected to know about such a system? That is why a commission with technical advisers is needed to handle such matters. Then, if our laws are reasonable, we can be pretty well certain that we will secure better traffic regulations in every city.

It may be of interest to note the value of the different transportation agencies using the streets in a few of our cities and for this purpose the following results of recent counts of traffic entering and leaving the central business districts of St. Louis, Baltimore and Chicago are presented:

NUMBER OF PASSENGERS

City	Total	Street Car	%	Passenger Auto*	%	Motor Bus	%
St. Louis (1925)...	493,588	315,536	63.9	142,819	28.9	35,233	7.1
Baltimore (1925)...	749,376	511,389	68.3	221,207	29.4	16,780	2.3
Chicago (1926)....	983,818	568,925	57.8	325,524	33.1	89,369	9.1
	2,226,782	1,395,850	62.7	689,550	30.9	141,382	6.4

Street Cars................. 62.7 per cent
Buses .... 6.4 " "

Mass transportation...... 69.1 " "
Passenger autos .... 30.9 " "

100.0 " "

*Includes taxicabs.

NOTE—In Chicago 1,693,506 passengers were counted, but 709,688 or 42% of this number, were carried by "off street" mass transportation agencies, elevated and steam suburban railway.

The number of mass transportation vehicles using the streets compared with the number of private automobiles was as follows:

NUMBER OF PASSENGER VEHICLES

City	Total	Mass Trans.	%	Passenger Auto	%
St. Louis	99,301	11,601	11.7	87,700	88.3
Baltimore	149,995	20,249	13.5	129,746	86.5
Chicago	201,380	20,534	10.2	180,846	89.8
	450,676	52,384	11.6	398,292	88.4

The similarity in the percentages is worthy of note.

Note—The St. Louis count was for an 11-hour period; the Baltimore count was for an 18-hour period, and the Chicago count was for a 12-hour period.

The following results of canvasses of customers entering the stores in the central business district of Detroit and Chicago show the relative value to the merchants of the different modes of transportation:

Customers	Chicago		Detroit	
Using elevated trains	32,419	33.8%	....	
Using street cars	25,191	26.2%	110,555	56.7%
Using suburban trains	18,742	19.5%	....	
Using motor buses	10,980	11.4%	48,251	24.2%
Using passenger autos	8,754	9.1%	36,272	19.1%
Total interviewed	96,086	100.0%*	195,078	100.0%

*Of the total customers, 1,505 or only 1.6% parked their autos on the streets.

Customers using mass transportation agencies	87,332	90.9%	158,806	80.9%
Customers using passenger autos, (including taxis)	8,754	9.1%	36,272	19.1%

Prevention of Coal Mine Explosions

A recently invented electrical detector of "fire damp" or methane, the combustible gas which is responsible for most coal mine explosions, has been called the most important forward safety step in the 20th century, and is expected by mine operators to put an end to much of the tremendous loss of human life in coal mine disasters.

The apparatus has been developed through cooperative research work instigated by coal mine operators and State legislators of Utah, who are using every possible means to put an end to suffering caused by past coal mine explosions in that State. Among the organizations which offered their services for this endeavor was the Union Carbide and Carbon Corporation. At its Long Island City Laboratories a group of men, led by Mr. E. K. Judd, has been working for two years on the idea that since combustible gas is the cause of the explosions, an automatic, accurate, and rugged detector of combustible gas would be the best possible means with which to avoid disastrous explosions.

Its basis is a platinum coil, about an inch long and five thousandths of an inch in diameter. When such a filament is heated to a constant temperature, it becomes slightly hotter in the presence of methane or other hydrocarbon gas. The more methane, the hotter the platinum coil gets. It is secured at the end of a stick and connected with a portable storage battery which heats it. The current from the battery is maintained constant by a simple automatic control, so any variation in the temperature of the coil is caused by the combustion of methane at the surface of the wire.

The temperature of the coil is then shown on a dial indicator, which is so calibrated to register the amount of methane in the atmosphere around the coil. In order to prevent an explosion, the coil is protected by the same gauze bonnets developed for a safety lamp a century ago by Sir Humphrey Davy.

Since it can be attached to a telescopic stick of any length, this sensitive instrument can be poked into the highest crevice on a mine level. The wires connecting it to the battery and indicator, of course, can be of any desired length. The battery and indicator are carried on the fire boss's belt. Indicators permanently placed in the entries could be wired to a recording device in the mine office, and could be made to ring warning signals, when the gas content rises above a safe point.

While the indicator registers immediately the presence of an increasing amount of methane in a steady action of the needle, if there is five per cent methane in the air (the danger point), the needle will swing back and forth rapidly.

The detector has met with unvarying success in both laboratory and field tests. Mr. Judd lately spent some time in the anthracite coal regions of Pennsylvania where he delighted coal mine operators and others concerned with the problem, by demonstrating its accuracy and quick action. Further demonstrations were held in Utah during the first of February.

DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Marked Improvement in Utilization of Fuel by Electric Public-Utility Power Plants in 1926

The total annual production of electricity by public-utility power plants in 1926 was 73,398,000,000 kilowatt-hours, an increase of 11.4 per cent over the output for 1925. Of this quantity about 35 per cent was produced by the use of water power, an increase of 1 per cent over that for 1926. Electricity produced by the use of fuel increased 9 per cent and by water power increased 16 per cent. It would have required more than 25,000,000 tons of coal to generate the electricity produced by water power.

There was a marked improvement in efficiency in the utilization of fuel in the production of electricity by these power plants in 1926. Although the increase in output by the use of fuels was 9 per cent, the increase in fuel consumption was only about 2 per cent. The average rate of consumption of coal in 1926 was 1.95 pounds per kilowatt-hour, showing a gain in efficiency of about 8 per cent during the year.

To have produced the electricity generated by the use of all fuels in 1926 by the use of coal alone would have required 46,400,000 tons at the average rate of coal consumption in 1926, or 76,000,000 tons at the average rate in 1919—a difference of nearly 30,000,000 tons. This figure indicates the immense saving in coal brought about by the improvements in the design and operation of public-utility power plants since 1919. At the present time at least one plant is using only about 0.85 pound of coal to produce a kilowatt-hour of electricity. If all the electricity produced by electric public utilities in 1926 by the use of fuels had been produced by the consumption of 0.85 pound of coal per kilowatt-hour, the conservation of coal would have amounted to 26,000,000 tons, which is equivalent to about $100,000,000.

Strengthening Highway and City Street Foundations to Meet the Increase in Motor-Bus and Truck Traffic

(*Continued from March issue, page 81*)

DISCUSSION

MR. ADLER: I need not remind you that as Chief of the Bureau of Highways of the third largest city of the country, Mr. Neeson has given careful consideration to a problem which this city evidently recognizes as a serious matter, and I am quite sure that his statements have aroused a number of questions in your minds that he will be very glad to answer.

MR. BAUM, City Engineer, Altoona: With regard to the efficiency of the mechanical tamping that is being used by the city of Philadelphia, is there any one type of mechanical tamper that is more efficient than another, and is it believed that by a system of mechanical tamping it is possible to restore the subgrade to about its original bearing power? It occurs to me here is a field that is very important for engineers belonging to municipalities, because we find so much difficulty in the impossibility of restoring cuts to the proper degree of bearing power.

MR. NEESON: I am glad you asked that question, because in the audience are some men who are giving particular study and attention to that feature of our work. I do not know that there is any one thing that appears not only embarrassing, but irritating to me, than a request to open a street that has been only recently paved. Our Board of Highway Supervisors has certain powers, but with limitations, and we have endeavored to set up rules and regulations that will prohibit the opening of a newly paved street for a reasonable length of time which we have set down as five years. Nevertheless, we must realize that service cuts must be made, we cannot sit by and not allow new property extensions, or enhancement of values, any more than we can stand by and prohibit the opening of a street for the repair of a water main, or some other underground structure, whether or not the paving has been down only a week. But in casting about for some efficient means of improvement over the old methods of merely depositing the dirt in the back fill, either tamping it by hand or puddling, we had several conferences with the representatives of the public utilities, their engineering forces, and we finally agreed upon the introduction of mechanical tamping. Of course, everybody will understand the theory and the desire to get all of the earth that has been removed back into the trench if it is possible. It is not possible to the extent of 100%. And still further to guarantee the integrity of the concrete paving over that trench, it was agreed at first that the cut back on the vertical plane should be one foot on either side of the original cut. Furthermore, the replacement of concrete was to be two inches extra in depth, but without any change in the mix. The results of the first year's observation were from our standpoint very satisfactory. Then, as a matter of economy, the utilities requested and received permission to cut down that cut-back vertical plane to six inches, and we are still operating under that agreement, but we feel that mechanical tamping and the absolute limitation of water, and almost the entire or complete removal of puddling in back fill, is essential to the future integrity of the ditch. And in making reference to a possible failure even of those methods, I believe that then the only solution of the problem will be the use of reinforcement.

MR. LYONS: Mr. Neeson's paper credits Pittsburgh with 1-2-3 concrete mix for base, 6" thick. We specify a minimum thickness or depth which we leave open and practically standardize on 8" and that standardization is 1-2-4 for base and 1-2-3 for curb. We use a lot of concrete curb for economical reasons, and it is 1-2-3 on the curb and 1-2-4 at present on the base.

MR. NEESON: Our standards today are 6" with a possibility of modification in the very near future, and our concrete curb is supposed to be without reinforcement, 1-2-4 as against 1-2-3.

MR. LYONS: We recently changed to the 1-2-3 and don't know yet whether it is good business or not.

MR. SYLVESTER, Philadelphia Electric Company: I do not pose as an expert on back-filling of ditches, but we have had a great deal of experience on the subject of mechanical tamping, and it was not until after we had demonstrated to our own satisfaction that we could restore all the earth taken out of a ditch, and more, that we made the appeal that we did to the city authorities. It was our contention that regardless of how wide you made the slab on the cut-back, if you didn't have a good back-fill, the side walls of your ditch wouldn't stand up, whereas if you had a substantially back-filled ditch, you could restore the paving foundation very satisfactorily and not cut back so much. I think we have demonstrated that very clearly within the last year. I know that in many cases where we have installed service connections, which consist of a creosoted wood pump log and laterals for pole connections, in advance of repaving, we demonstrated very clearly that by the use of mechanical tampers we can restore all the dirt we take out, and in many cases we have had to send elsewhere for dirt to bring the ditch back to the original surface. Indicating very clearly to us that by means of mechanical tamping we can put in just as good a foundation as the ditch originally had.

MR. BAUM: The one thought I had in mind was that not only in the restoring of cuts, but in the treatment of new trenches put down in advance of paving, for instance one or two years ahead, whether the City has found it necessary to use mechanical tamping or depends entirely on puddling. In many cases there are two or three longitudinal trenches, and many lateral trenches, to serve the properties, and unless these are put back nearly to the original bearing power, it disturbs the theory of uniform support for the pavement.

MR. ADLER: The remarks of Mr. Baum open a big field for difference of opinion and further discussion, and I cannot resist the temptation to pursue that part of the subject a little bit further. It seems quite evident that we have already divided into two camps, one which believes in immediate increase in strength of foundations by means of thickening, or richer mixtures, or both; and the other which calls attention to the necessity for starting with improved sub-grade conditions as Chief Neeson has suggested, or of adopting other means as Mr. Pollock, of New York, suggested, of improving the sub-grade in order to overcome frost action. In Philadelphia in the replacement of existing pavements as distinguished from the original pavements, it has been found possible by the leading utility companies, employing mechanical tampers, to back-fill their ditches so as to replace all of the material excavated from it, and sometimes more. When you come to the question of original paving, though, you have an entirely different situation. In other words, the ditches that are open in such streets before the first or original paving is placed, may be opened by any one of a number of different individuals, either public utility companies, builders, plumbers, or others, and Chief Neeson has told us that his idea is to call for a more general use of mechanical tamping prior to paving. The question Mr. Baum is leading up to, is just what possiblity Mr. Neeson sees as the necessity of taking care of ditches opened on streets which have never had a paving, where those ditches are opened by many persons or corporations who are in no way responsible to the organization having charge of the paving of the street. Would you mind going into that further, Mr. Neeson?

MR. NEESON: Of course, there is no use of public utilities expending their own money in an effort to provide better conditions on sub-grade if we are not to make the rule universal. And as it applies to plumbers and other persons (who are in the minority, however; plumbers are in the great majority) who make openings in streets, etc., prior to paving or repaving. At the present time, the method is extremely lax, and we have endeavored for the past two years, in producing or sending our budget to Council, to have legislation enacted that will give us additional funds without the Council actually appropriating them. At the present time, anyone can secure a permit for opening the street for the trifling sum of $20.00, and thereafter his responsibility ceases. It is a part of the duty of the maintenance force of the organization to take care of that ditch and to restore it to its original surface. That, in itself, is dependent upon a good many things —upon the activity of the various units in the district, the schedule of the work laid out for them, and their ability to reach this ditch in a reasonable length of time, after it has been restored merely by back-filling, —and in the meantime, of course, almost anything is likely to happen in the way of an accident or damage to personal property, which on investigation shows alarming results. The answer, I think, can be very quickly pointed out in the damages that have been paid for accidents, real and alleged, as the result of improper back-filling or not taking care immediately of a trench cut—in nearly all cases, those of plumbers. In our proposed solution of that porposition, in order to make it fit in and have the whole operation of the rule universal throughout the entire city, it was our idea to ask the legislative body to give us direct the money that is paid into the City Treasury for each one of these openings. It is a trifling sum, as sums go now in maintenance. It amounts to less than $140,000 per annum, but we cannot secure it. But if we did, we would be able then, to send out a special unit that might cover one or even two districts, thus giving us an opportunity to employ the same methods that the utilities are utilizing now in making that back-fill as perfect as it can be made, and restoring every ounce of dirt that came out of the hole. That is the only salvation in that particular field of preparation of sub-grade. We see streets today that are paved, and where cuts have been made within the last three or four years, just in advance of paving, by public utilities, where the restoration has been made by this improved method, and that paving will not fail in that particular spot any more than it will fail over a perfect sub-grade.

MR. ADLER: Ditches for sewers and water pipes, gas mains, conduits, and various lateral connections, in unpaved streets generally precede or accompany building operations on those streets, and unfortunately, in a great many cases precede the paving of the street by entirely too short a period of time to permit of any real settlement and compaction adequate for paving. I hope that as this meeting goes on some of the municipalities represented here will tell us just exactly how they are handling that problem in their particular localities, because I think it is something that is very vital to the discussion before we finally decide to incur once and for all, an additional expenditure of perhaps $10,000 per mile on 26-foot wide streets for heavier foundations.

Survey of Present Paving Situation in New York

By R. A. MacGREGOR

Engineer of Maintenance, Borough of Manhattan, N. Y.

WHILE speaking principally of conditions in Manhattan, I have been enabled to get some data from the other Boroughs of New York City.

The total mileage of paved streets in New York is between 2,100 and 2,200 miles with an area of 42½ million square yards.

The traffic conditions vary from the lightest possible, a few delivery vans per day, to the most intense, or at least as intense, as any in the United States.

The subsurface conditions also vary as might be expected, but generally owing to the established practice of building sewers and laying water mains by the City and the construction to a considerable extent of duct lines, before the paving is done, the roadbed is well provided with drainage. This eliminates any general disturbance from freezing, which in many localities works serious damage to both concrete foundation and wearing surface.

The standard foundation for pavements is concrete 6" thick. This is required for pavements to be classed by the Board of Estimate and Apportionment as permanent, and for which the abutting property having been assessed cannot be assessed for subsequent repaving.

Pavements with foundations of less than 6" of concrete are classed as temporary and the cost of these is assessed as well as the cost of the subsequent repaving, the property, however, being credited with the payment made by the first pavement, thus in theory at least, the property in New York City is assessed only for the first pavement.

As concrete foundation 6" thick, in this way, is considered the standard, practically all the pavements laid as first pavement have 6" base. The Borough of the Bronx still holds to this thickness. The Borough of Brooklyn does also. I believe the Borough of Queens lays concrete foundations 6" thick, but a speaker from Queens is here, or expects to be, and he will speak for the Borough. The Engineers of Brooklyn and the Bronx state that 6" thickness has been found sufficient and there is no intention to at present increase the thickness.

In Manhattan practically all streets are now paved, less than 10 miles out of 490 being still unpaved. In repaving 6" is still the usual thickness, but where traffic is heavy and likely to increase both as to wheel loads and to density 9" foundation is used.

In nearly all streets repaved, duct lines and gas mains have been laid or repaired just ahead of repaving, thus making the sub-grade a series of recently filled trenches. To take care of this situation, the foundation is made 9" thick on streets with heavy traffic loads at the present time, or expected during the life of the wearing surface and about 22 miles have been so laid in 1925 and 1926. In other cases, the foundation is as thick or even thicker, due to changes of grade and the placing of additional concrete to bring the new pavement to proper grade and crown.

A study of the relative costs and values of increased thickness of plain concrete and of reinforced concrete was made some time ago by the Department, for the purpose of deciding on a policy.

It was found that 9" thickness of plain 1-3-6 concrete would give more than double the strength of 6" at a cost of 50% increase; that a 4" thickness reinforced would give nearly three times the strength of 6" plain at less cost than 6" plain concrete; that a 6" thickness properly proportioned reinforced would give nearly 7 times the strength for a 25% increase of cost.

These results as to cost would vary quite considerably in other locations due to lower labor, transportation and disposal costs. In Manhattan practically all excavated material has to be disposed of by loading on scows and dumping at sea, or for filling in under water around the harbor. The price of the dumping runs about $1.00 per cubic yard.

Transportation costs are also high, due to congestion at the loading piers and the price used in the calculation mentioned, $4.00 per cubic yard of excavation was not at all extravagant.

Another consideration is the difficulty of making and restoring cuts. While the labor and cost of replacing reinforced concrete would be increased, the result would to a large extent be a stronger slab over the cut without any better connection to the adjoining old concrete. The settlement of backfilling would still allow the new slab to sink.

The calculations mentioned were based on a uniform safe load on a 6-foot span. Such a span is quite often found; cases of much greater span up to 13 and 14 feet over cavities large enough to stand up in have been found and this with old 6" concrete.

With the modern methods of mixing and better inspection, our 6" foundations have improved though perhaps not as rapidly or as much as the amount of traffic, and to get rid of the annoyance and interruption of traffic, the use of 9" concrete was begun for streets as outlined above.

I might say that our records for cave-ins (as we call them) which require restoration of the concrete foundation may not justify the increase to 9", a great many settlements are taken care of by adding to the depth of asphalt pavement or by adding to the bed in granite pavements, while repairs are being made.

The practice in Manhattan is to repave over openings as soon as possible after backfilling. This is done generally within 10 or 12 days, the concrete being laid 2 or 3 days sooner and immediately opened to traffic with only 3 or 4 inches of earth on top as protection. It is only very rarely found that the concrete is not set up sound and hard when cleaned off for asphalting. Examination of settlements over trenches also shows in most cases sound, hard concrete, with a settlement of the slab following the sunken backfill.

The policy has been to get as nearly as possible the full value out of the cement and changes have been made in the specifications from year to year following experiments showing improved methods.

Batch mixers have long been required, greater care in measuring the aggregate by the use of standard wheel barrows because measuring boxes are not practicable; now most of the aggregates are measured as they are loaded into the trucks. The latter having partitions and the required quantities of coarse and fine aggregate for one batch are loaded into each compartment from overhead bins. The cement is usually delivered separately on the street and the proper number of bags added to the hopper after the batch of aggregates has been dumped into it from the truck.

Another recent advance in the specifications is the fixing of the amount of water to be added to a batch for each bag of cement used. This is in line with recent tests made by cement experts.

The average age of pavements at date of replacement is now about 26 years for granite blocks and 18 for sheet asphalt. About 500,000 yards of granite and 600,000 yards of asphalt laid before 1900 are still in existence and of this about 215,300 square yards of granite were laid before 1890.

Total Area: Sheet Asphalt—5,670,000 sq. yds.—280 miles.
Granite —2,838,000 sq. yds.—134 miles.

This is perhaps all that is necessary to say as to the present situation in New York, but I will be glad to answer, or try to answer, any question in regard to Manhattan conditions or practice.

DISCUSSION

MR. ADLER: It is very interesting to note that with the extremely heavy traffic with which the city of New York is credited, Manhattan still has a very large mileage of pavements with six inch base, of which about 50% has been done in the last few years. I understand that only in the sections of the city where traffic is both heavy and congested has the Borough of Manhattan employed the increased thickness of nine inches. Of course we must bear in mind that sub-grade conditions in Manhattan are probably different from those in Philadelphia and Pittsburgh, and I think it might be of interest at this moment if Mr. MacGregor would give us some idea of the average depth to rock of sub-grade pavements in Manhattan, realizing, of course, that it varies very materially in different parts of the borough.

MR. MacGREGOR: In the upper part of the borough we have plenty of rock. In the southern half, the overlying part is practically all gravel, that is, sand and gravel, and, of course, gives very good drainage. In regard to the work of the utility corporations, that varies. One of the companies has an exceedingly small amount of double restoration to make. They place material in the trench very thoroughly, but all are required and expected to maintain the pavement for at least a year after original restoration, and we require them to restore the pavement and keep it restored until at least that year has expired. A recent survey and report was made of those settlements which required immediate attention to obviate accidents. Without having exact figures I should say about 90% of these are settlements over trenches, and the number of cases where the concrete was worthless is almost infinitesimal. The concrete slab almost invariably is good and has gone down; and that examination is valuable because the bulk of the restoration, or a very large proportion, were at fault, and the concrete therefore had to be cleaned off. We find that concrete in good condition, though it is at once covered up with earth to protect it from traffic and opened to traffic. We do not barricade our cuts at all; we open them at once, after concreting, and in forty-eight hours, if possible, we restore the wearing surface, and though in some cases we find wheel tracks in that concrete, the concrete is good. The astonishing thing to me is that the old concrete, concrete laid fifteen or twenty years ago, when methods of inspection were not as good as they have been for the past ten or fifteen years, stands up as well as it does. In many places are spans of 13 and 14 feet where the break-up started by a wheel going down and making a small hole two or three feet in diameter. But we have efficient inspection now. But, as Mr. Neeson mentioned, we have the difficulty of getting good refilling on plumbers' openings. Plumbers' openings are enormous in number in Manhattan, and we have not enough of an appropriation to inspect them, and we haven't legislative methods to enable us to do the back-filling, so the back-filling is done by the plumber. However, the plumber deposits in money double the estimated cost of repaving the cut; he back-fills, and we immediately restore the paving, and refund to him the difference between the cost and one-half the deposit. We then retain the other half for six months, and if a settlement occurs we use that second half for the restoration. If it does not occur within six months (and very few as a matter of fact—less than a fraction of 1% occur after that period) he gets back his entire second half.

MR. SILVERMAN, of Philadelphia: I would like to ask Mr. MacGregor about the methods employed for the restoration of the back fills in these plumbers' openings, and particularly opening made in rock.

MR. MacGREGOR: The question of back fill in regard to plumbers' openings is pretty much a case of dumping the back fill in. However, the plumbers generally do a little tamping, and more often flushing is the favorite method, and on account of the good drainage we have, that is quite permissible.

MR. SKILTON: I would like to ask Mr. MacGregor if I understood him rightly to say that in replacing concrete in a cut, the concrete is placed and immediately covered with earth and traffic allowed to go over it.

MR. MacGREGOR: Yes. We couldn't afford to barricade traffic twenty-four hours in Manhattan. In fact, I think that our "front office," as I call it, would like us to restore the cut before it is made.

MR. SKILTON: I do not see how you get traffic going over that fresh concrete.

MR. MacGREGOR: The work is done in the morning, the gangs are there, and they may leave the back fill alongside the cut, so that we protect the concrete until afternoon, when we clean up. Then it is covered with fresh earth, and the traffic misses it as much as possible. Nobody wants to go into a muddy cut or an earth cut, so it is missed, and it gets almost twenty-four hours to set without very much disturbance. As a matter of fact, we very often allow soft tire traffic on repaving work to go in the next morning if it is absolutely necessary; if there is no other entrance to a business house, we let in a soft-tired truck, or automobile, the next day, without any serious damage to the pavement or apparent damage to the concrete. Just now we are considering the use of the average strength cement for particular locations such as intersections. In that way, instead of taking four bites of an intersection, we might do it all in one day or in two days; but generally, we do not allow the closing up of an entire intersection. Intersections are skipped and only one-half is taken. Then the other half is left for sometime, or is taken immediately after.

MR. SKILTON: I would like to ask another question: You speak of the age of replacing of pavements—asphalt as 18 years, and granite blocks as 26 years, average length of life. Now just what was the failure in the case of the granite block? What is the reason for that? Is it wear, or because they are old pavements and too rough for modern traffic?

MR. MacGREGOR: The old granite pavements replaced are the old style block, nine inches deep, and with inch, or inch and a quarter joints, which gives a rough pavement. The close, well dressed pavement, 5" block, has been laid only since 1912, and none of those have been replaced. Some of it has been worn out, however, and I have in mind one or two streets where our men are turning the blocks up on the edge because they are too thin to go back the way they are, and they get 4½" depth. These streets will have to be repaved because the blocks are splitting now under the new loads.

MR. SKILTON: What proportion of these replacements would you say is due to the block being old and laid in a more or less rough fashion? How does that compare with actual wear as you speak of now?

MR. MacGREGOR: The old style pavements that are replaced have to be replaced on account of having been cut to pieces with trenches.

MR. SKILTON: Not really any wearing out, then?

MR. MacGREGOR: Not generally. The old pavements do not show very much wear, except cobbling. Of course, it is very rough through constant repair by the repair gangs.

MR. ANDERS, of Newark: I would like to ask Mr. MacGregor if he has ever used black base in the repair of cuts. We have used it to some extent in Newark with good results.

MR. MacGREGOR: We have used black base on Fifth Avenue and one or two other streets as a repair method, and have had pretty good results. However, you have to figure on a settlement or compaction of that to the extent of about one inch. The black base is five or six inches thick of binder and the standard inch and a half top. That binder can not be compacted, and in addition to that it holds the heat, so that the entire batch is not as well rolled as it would otherwise be. Traffic eventually compresses it, and the cut shows a slight depression. But we are not making a general practice of that except on one or two avenues. It saves one operation. As a matter of fact it saves two or three days, actually, in the restoration of a cut, because the concrete foundation takes one day, and the notification to the office and ordering out the asphalt gang takes another day at least, so that interruptions to traffic are reduced by two or three days.

(Record will be continued in May issue.)

The Business Situation

As the year advances there appears to be a greater confidence on the part of all authorities that with the exception of a few special lines, the outlook for 1927 is constantly improving. The April letters and publications of the principal financial interests all carry the same note as will be seen by the following abstracts:

The Guaranty Trust Company of New York

"The rate of general business activity has continued its gradual advance during the last few weeks, while in several basic industries the expansion has been very pronounced. These developments have strengthened confidence in the fundamental soundness of present conditions and in the outlook for a continuance of active business for the next few months. It remains true, however, that the volume of trade for the entire country appears to be somewhat smaller than a year ago.

"Among the leading industries, the most significant trend is that of iron and steel manufacture, in which the present rate of activity is nearly, if not quite, the highest in the history of the industry.

"The situation in the automobile industry is also encouraging, despite a few recent price reductions by manufacturers. Building activity showed a distinct gain in February, new construction undertaken during the month having been somewhat larger than the total for February 1926.

"The cotton textile industry continues to operate at a high level, without any apparent tendency toward over-production.

"Financial conditions remain strong, with money rates at virtually the same level as prevailed a month ago. Aside from the temporary effects of the Treasury financing on March 15th, there has been no important change in the position of the banks during the last few weeks.

"The foreign trade of the United States for the month of February resulted in another large export balance.

"A striking feature of our foreign trade for 1926 was the important gains in trade with the Far East, South America and Africa, and the comparatively large merchandise excess of imports received from those parts of the world. The United States not only sold more goods to the countries of the Far East during 1926, but also imported more merchandise from them, thereby enabling the Orient to maintain the leadership established in 1925 as the principal source of American imports.

"Latin-American countries sold to the United States about $200,000,000 more goods last year than this country sold them. This apparent adverse trade balance is, of course, offset to a great extent by large American investments and by other invisible exports."

The National City Bank of New York

"The month of March has strengthened the convictions of those who believe that the factors making for good business are still in the ascendancy. Late in 1926 business experienced some let-up which was cause for considerable questioning among business men as to whether the long expected termination of prosperity was not at hand. Since the new year, however, business has been slowly but steadily improving, until it is now pretty clear that the recovery has been genuine.

"Clearly business generally is still above the normal, and there is nothing now in sight to indicate that it may not go on this way for some time. That it will overtop the record of 1926 seems unlikely in view of the improbability of a further expansion in the building and automobile industries. That it will fall seriously below that of 1926 seems equally unlikely so long as credit supplies continue in their present abundance.

"The general tendency of commodity prices has continued downward as indicated by Professor Fisher's index of 205 articles which in the week of March 20 touched 139.6 per cent of the 1913 average, the lowest in five years and almost down to the post-war low point of 138 reached in January, 1922.

"The decline of prices, it is interesting to note, has not been confined to this country, but has been in evidence in foreign countries as well. The sweeping declines enabling business to be carried on with a smaller volume of bank credit explain, in part at least, the decline in money rates that has been equally widespread over the same period.

"While business volume continues at high levels, complaints as to the inadequacy of business profits continue to be heard, and apprehension is frequently expressed as to the effect of the continued decline of prices on earnings. Undoubtedly a period of falling prices does increase the difficulties of doing business, but before placing too much reliance on much that is heard regarding profits it would be well to recall that complaints on this score were no less numerous early in 1926, a year which is now demonstrated, both by corporation statements and by income tax returns, to have been one of the most prosperous on record. Business is constantly changing, and the state of the textile industry during the past few years is an impressive reminder that all lines are seldom prosperous at the same time. There is always someone who is not getting his full share of the business, and his complaints are usually more audible than the expressions of those who are.

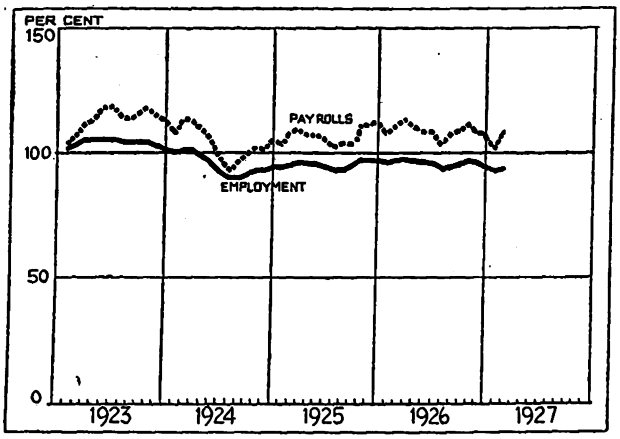
"With the United States Steel Corporation operating practically at capacity and the industry as a whole averaging around 95 per cent at the end of March the month will come close to setting a new record for steel production. Some of this activity is undoubtedly due to stocking of steel against the coal strike, but real demand has been good for a broad line of products. Prices, which weakened considerably earlier in the year, have been much steadier, and scrap and pig iron have advanced somewhat on strike prospects.

"With gold stocks of the country at new high levels, and Federal reserve credit outstanding at the lowest levels since 1924, the outlook is for a continued ample supply of funds for business purposes. During the next few months seasonal tendencies will be in the direction of further ease of rates. A factor, however, which may modify these tendencies is the possibility of gold exports to Canada. Canadian exchange, on prospect of an early opening of navigation, is moving rapidly towards the gold export point for this country. Last April we shipped $16,000,000 in gold to Canada, and there is the possibility of a similar movement this year which would tend to diminish excess funds in this market."

Federal Reserve Bank of New York

"Industrial output increased further in February and was slightly larger than a year ago, and distribution of commodities by the railroads was larger than for the corresponding period of any previous year. The general level of wholesale prices continued to decline and was in February at the lowest level since the summer of 1924.

"Retail trade showed less than the usual seasonal decline between January and February. Sales of department stores and chain stores were larger than in February of last year, while those of mail order houses were smaller. Wholesale firms reported a smaller volume of business in February than a year ago, and this decline occurred in nearly all leading lines. Inventories of department stores increased in February in anticipation of the usual expansion in spring trade, but the growth was less than is customary at this season and at the end of the month stocks were slightly smaller than a year ago.



FACTORY EMPLOYMENT AND PAYROLL

FEDERAL RESERVE BOARD'S INDEXES OF FACTORY EMPLOYMENT AND PAYROLLS. (1919 AVERAGE = 100 PER CENT.) LATEST FIGURES FEBRUARY, 1927: EMPLOYMENT, 93.7; PAYROLL, 108.5.

"Conditions in the money market in March were slightly firmer than in February. Rates on prime commercial paper advanced from 4 per cent to 4-4½ per cent and call money was also higher, while rates on acceptances declined somewhat.

"Aside from Treasury operations there was during March a somewhat firmer tendency apparent in the money market, due in part to a seasonal increase in the demand for funds for commercial use and an increase in the amount of credit employed in the security markets.

"Net profits of 403 industrial and mercantile corporations in 1926 averaged 11 per cent larger than in 1925, and 50 per cent larger than in 1924. The increases over the preceding year were not as consistent as in 1925."

The whole situation as to business conditions in the United States is well summed up in one sentence in the Magazine of Wall Street:

"Altogether, the numerous cross currents now extant tend to stress the attitude of conservatism that has marked business for months past. Spring requirements will doubtless continue to sustain activity in the near future with prospects of moderate recession later."

C. E. B.

Items of Interest

An American Engineer Honored

Morris L. Cooke, distinguished American engineer, has recently been honored by the Czechoslovak Government, as set forth in the following letter received by him from the Czechoslovak Legation, Washington, D. C., dated March 28th, 1927, reading as follows:

My Dear Mr. Cooke:

I have the honor to inform you that the President of the Czechoslovak Republic, in full consideration of the eminent services rendered by you to the Czechoslovak State, with his decision of February 18th, 1927, has awarded to you **the Cross of Knight of the Czechoslovak Order of the White Lion.** The insignia of the order immediately after their receipt will be forwarded to the State Department of the United States in Washington with the request to follow the usual procedure in such case according to the existing laws and rules.

Allow me, my dear Mr. Cooke, to congratulate you and to express the assurance of my high consideration.

(Signed) Zdenek Fierlinger,

Envoy Extraordinary and Minister Plenipotentiary of the Czechoslovak Republic.

Metropolitan Street Traffic

The problem of traffic in metropolitan areas not only troubles, but actually threatens every large city. Visit an international city planning convention or a world wide conference of police officials. What does one learn about solving traffic congestion? Very little, indeed! All are overwhelmed by the street problem. Every city, American or foreign, comes a-begging. All confess failure in coping with it, and each earnestly seeks some traffic plan possessed with the powers of Aladdin's lamp. Not a few cities and metropolitan districts have come to realize that each must themselves work out its own solution of this problem. They have, therefore, made or are making, extensive traffic surveys. A new agency, which has assisted several cities in traffic studies, is the Albert Russell Erskine Bureau for Traffic, which has recently been established in Harvard University. This Bureau proposes to make extensive investigation of traffic problems in American cities and to publish from time to time the results of these findings. That complete relief from the present intolerable congestion, or that wholly adequate provisions for its prevention in the future may result from this effort, is not to be expected, but it is reasonably certain that cities buttressed by sound facts will go far toward their goal.

What the city of Chicago is doing to arrive at complete understanding of its traffic condition is notable. The City Plan Commission's part is well known and is highly creditable. A valuable survey known as a "Report of a Study of Highway Traffic and the Highway System of Cook County" was prepared jointly by the United States Bureau of Public Roads and the Cook County Highway Department in 1925. Now comes the Chicago Association of Commerce's "Report and Recommendations for the Metropolitan Street Traffic Survey" by Miller McClintock (Chicago Association of Commerce, 1926, 291 p.). This engineering study of street traffic conditions, embodying suggestions for a comprehensive traffic plan and a uniform code for the Chicago Metropolitan area was made in response to a request of the City Council. A committee representative of the important traffic interests of the city was appointed and the services of Dr. Miller McClintock, Director of the Albert Russell Erskine Bureau for Street Traffic Research were secured for this important task. An appropriation of $50,000 was then made by the Chamber to further its project.

The area covered by the survey includes the territory lying within an approximate forty-mile radius of State and Madison Street, which it designates as the Chicago Automotive Region. The population of this area exceeds 4,000,000.

The recommendations of the report relative to administrative organization and procedure are:

1. A Greater Chicago Street Traffic Commission composed of Mayor and 12 officials and representatives of governmental agencies, which are specified in the report.
2. A division of traffic engineering as a part of the Bureau of Streets of the Department of Public Works.
3. A reorganization of the Traffic Division of the Police Department.
4. Provision for a firmer and more systematic enforcement of traffic laws in the courts.
5. Certain recommendations in connection with traffic signs and signals.

The Association also offers for Chicago a carefully drafted traffic ordinance, which it proposes for adoption. All these recommendations are worked out in detail. More than forty tables and some fifty charts and illustrations add to the value of this survey.

Municipal Airports

The era of air transportation is slowly, but surely, beginning in the United States. If we are rather far behind the Continental air service developments in many respects, we have made what progress has been achieved without the aid of federal subsidies. Now that the Kelly Air-Mail Contract Law, and the Air Commerce Act, have been written into the law of the land, we have, undoubtedly, prepared the way for a well-regulated and an early developed air commerce.

At the annual meeting of the Aeronautical Executive Association, it was predicted that Canada and United States would be linked by air in 1927. "We have the right kind of pilots and airplanes in commercial use, but we must have more airports."

Of the 3,608 landing fields and airports reported by the Aircraft Yearbook of 1926, 310 are listed as municipal airports. But many of these are unimproved fields. The Kelly Mail Act, however, has stimulated many cities into action, causing them to set their fields in order that they might thereby obtain air mail routes.

The year 1925 was a year of definite progress. Aviation became something more than barnstorming. It received recognition as a business by the entrance of some of our foremost capitalists and saw large financial investment in air transport systems. During the year, close to five and a half million miles were flown and over 200,000 passengers were carried. Twelve air mail routes (mileage of about 5,500) were let to private operators. At the beginning of 1926 nearly 9,000 miles of commercial airways were in regular operation in the United States. In a year and a half of the Airmail service ending December 31, 1925, 16,414,296 letters were carried, $1,037,524 excess postage being collected. Out of this sixteen and one-half million letters only 4,000 were lost. Certainly a marvelous record, when one remembers that the mail planes must fly day and night in all weather, over mountains and through blizzards and cyclone regions.

When the statistical data for 1926 and 1927 become available, indications are that it will reveal satisfactory progress. Air Express will have become an established system of transportation. The close of 1927 may see passenger transportation assume important proportions.

That cities are becoming increasingly aware of the importance of being linked successfully to Airways is evident. As the Government is definitely pledged to put the air mail transportation in private hands and has taken over the regulation of the Airways there is every incentive for those cities, alert to advantages to be gained by an adequate airport, to push to completion or enlarge their present airfields.

Cleveland is one of the cities that has seen to it that its airport is large enough and sufficiently well planned to place it definitely on the Airway map for some years to come. Legal obstacles were hurdled, $1,125,000 was appropriated and 750 acres purchased. On July 1, 1926, after one year of operation, 4,000 planes had landed and taken off from the Cleveland airport. St. Paul issued bonds for $295,000 for the development of an airport. The port opened on June 7, 1926, ready for the use of Mail planes on the Chicago-Twin City route. It is admirably situated both for aeronautical and commercial purposes. The San Francisco Regional Plan Association is advocating a Metropolitan aviation center on the Embargo. It is proposed that an Airport landing platform 150 to 200 feet above the high water mark and about 1,000 feet by 1,000 feet in extent be built over the wharves. It is also proposed to build in conjunction an elevated highway similar to the structure planned for New York. This roadway would be built along the wharves past the Airport. The scale of the plans for Elevated airport appears to be on the dimensions of those great foreign airports such as Croydon for London, Le Bourget for Paris or that of Tempelhofer in Berlin.

The activities of a half dozen other cities might be mentioned here. But the question comes closer home. What is Philadelphia doing about an airport? As yet, not very much.

The Elements of Metal Cutting

This paper gives an account of an investigation in the fundamental elements of metal cutting conducted during five years in the Machine Tool Laboratory at the University of Michigan. The object of the investigation was to determine a relation between the force on the tool in the direction of cut for a constant cutting speed of 20 feet per minute, and the degree of tool sharpness, the various tool angles, the width and depth of cut, and the physical properties of the materials cut. Nine representative types of material were cut including three carbon steels, three alloy steels, brass, and annealed and unannealed cast iron. The cutting was confined to straight-line motion on a planer, and the tools used were of the end-cutting type. No cutting fluids were used, and but one element was varied at a time.

The results show that the clearance angle has no influence on the force on the tool so long as the tool does not drag on the work; that the force on the tool remains constant for a wide variation of keenness of cutting edge and for thick chips, particularly, the tool edge may be rounded to 1/64 in. diameter without appreciable increase in the cutting force. It is also shown that the cutting force on the tool is reduced in direct proportion to the increase in front-rake angle, all other factors remaining constant. It is shown that thick chips are removed more efficiently than thin chips, and that narrow chips are removed more efficiently than wide chips. The results also indicate that there is an apparent relation between some of the physical properties of the metals and their machinability, or the cutting force on the tool, for the carbon steels in one group, the alloy steels in a second group, and cast iron in a third group.

—Michigan Engineering Research Bulletin No. 5.

A 10th of a 1,000th of a 1,000,000th of an Ampere

An instrument that indicates a change in current as small as a tenth of a thousandth of a millionth part of an ampere has been developed in the standardizing laboratory at West Lynn, Mass., as a part of the equipment which replaces the human eye in making tests on incandescent lamps, currents in insulators, radio tubes, etc. The instrument, known as a thermionic microammeter, has a full-scale reading of a tenth of a millionth of an ampere, with subdivisions of one five-hundredth of this amount. It is the most sensitive instrument of such a long scale length working on jewel bearings that has ever been built.

The lamp divisions of the General Electric Company at Harrison, N. J., and Cleveland have combined this microammeter with the photoelectric cell in the development of photometric apparatus which is far more susceptible to variations in intensity of light than is the human eye. The light output of lamps in the past has been measured by visually contrasting the amount of light given by the lamp in question with a known amount of light given by a standard lamp. Such a method is far less accurate than the new method, in which the human eye has been replaced by the electric eye—the photoelectric cell—and the individual is required only to make scale readings of lumens or candlepower in the same manner as he would read volts or amperes on an ordinary laboratory standard instrument.

The photoelectric cell is a vacuum tube which is extremely sensitive to any changes of intensity of light falling upon it, due to the fact that its internal resistance varies with the intensity of the light reaching it. This property of the cell has been utilized in many ways, such as in transmitting photographs by radio, in making talking motion pictures, in an improved method for manufacturing phonograph records, and in different methods for accurately matching colors.

Except for a small circular area, the inside of the bulb of the cell glistens with metallic potassium. Depending upon the amount of light striking it, this metal permits a varying amount of current to pass through the cell. The more light, the more current; each little increase in the amount of light striking the window of the cell is almost immediately responsible for an infinitesimal increase in the amount of current passing through the circuit of the cell.

For use in photometry, the photoelectric cell is located on the exterior of a spherical photometer, or Ulbricht sphere, with its window adjacent to the small window in the surface of the photometer. The photoelectric cell and the microammeter are then connected in series across an ordinary radio "B" battery, of 45, 90 or 135 volts. In this manner the amount of light given off by the lamp under test lowers the resistance of the cell, causing a current to flow through the photoelectric cell and microammeter circuit and, in turn, produces a deflection on the microammeter scale.

Completion of First Hole of Moffat Tunnel

President Coolidge, by remote control, set off the blast which broke down the last barrier between the two bores of the preliminary work of the Moffat Tunnel, on Friday night, February 18, at 8:10 o'clock Mountain Standard Time.

The preliminary tunnel, completed by this blast, is eight feet in diameter and has served as an exploration tube and, later, will be used as an aqueduct to carry water from the high western plateau into Denver. Following closely on its heels is the construction work on the main tunnel, whose dimensions will be 24 feet by 16 feet.

The Moffat tunnel, boring under the Continental Divide, will be 6.04 miles long, the second longest tunnel in the world. It will be three miles shorter than that of St. Gothard under the Alps. Its completion will mark the culmination of an heroic struggle for the construction of a transcontinental route through Colorado, running from Denver to Salt Lake City. It will open the western slope of the Rocky Mountain to all-year traffic, connecting in the west with Moffat's original railroad below the snow blockage line. On the eastern side it enters the mountain at a point about 50 miles from Denver at an elevation of 9,198 feet. Near the middle of the tunnel the elevation is 9,222 feet—a peak or high point to allow ready drainage. The western portal has an elevation of 9,085 feet. The center of the tunnel is 4,160 feet below the top of James Peak. The grade on the eastern side is 0.3 per cent and, on the western side, 0.9 per cent. The tunnel passes directly under the Crater Lakes on top of the Continental Divide, locally reputed to be bottomless.

With the utilization of the proposed Dotsero cut-off, a 41-mile branch railroad to be built from the west portal of the tunnel, the distance from Glenwood Springs, on the west slope, to Denver, will be reduced from 343 to 173 miles. The tunnel will eliminate 23 miles of the railroad over Corona Pass, practically all of which is above timber line on a 4 per cent grade; will cut down the elevation by 2,406 feet, and reduce grades to 2 per cent.

The Moffat tunnel, in addition to its two railroad tracks, will be traversed by telephone, telegraph and power cables important to the life of the Rocky Mountain section. Automobiles will be carried through on flat cars, allowing motorists to make the trip over the divide at all seasons. Present automobile highways between eastern and western Colorado cross the Divide by means of passes which are blocked half the year by snow. The railroad in the tunnel will be electrified, electric locomotives hauling the trains. The steam locomotives will have their fires banked and will be hauled through with the trains.

Tunnel construction work was started in October, 1923, under the direction of the Moffat Tunnel Commission and Tunnel District of Colorado. About 4,000 horsepower in electric motors has been and is being used in the work; motor generators and motor-driven compressors furnish light and power for excavation and construction; electric locomotives provide haulage facilities, and electric transformers supply power at proper voltages from electric transmission lines. The date originally specified for completion of the entire work is July 20, 1927.

Gasoline Substitutes Will Be Available if Petroleum Supply Dwindles

A review of the motor fuel situation suggests the thought that, unless the discovery of new fields terminates with unexpected suddenness, the decline in crude-oil production, when it comes, will be gradual, and that from time to time, other materials will enter into competition with petroleum and add to the supply of available materials, states A. J. Kraemer, associate petroleum chemist, Bureau of Mines, in Information Circular 6015, recently issued. When, or if, the supply of petroleum becomes practically exhausted, the methods of production of alternative products (shale oil, alcohol, coal distillates, etc.) will probably be so much advanced over the present state of the art, that there will be no great hardship in the change.

In practically all oil fields, the greater part of the oil is left in the sands, when present methods of flowing and pumping have extracted all that it is economically possible to extract. It has been estimated that, in general, one-seventh of the oil has been recovered by old processes, another seventh seems possible by present commercial practices for rejuvenating depleted oil fields, another two-sevenths seems possible by improvement in present rejuvenating processes and three-sevenths can be recovered only by radical improvements over methods now in use.

The oil industry has been much interested in this question of increasing the recovery of oil from oil sands. Several companies, as well as the Bureau of Mines, and the U. S. Geological Survey, are studying the question, and considerable progress has been made in increasing recoveries by restoring gas pressure and by other means.

What form of motor fuel the future will demand is uncertain. When cracked gasoline was a new product it was looked upon with suspicion, and regarded as inferior to straight-run gasoline. This view has now been reversed, and the oil industry is steadily increasing its cracking equipment. It is not unreasonable to surmise that in the future the demand may be for a heavier, less volatile fuel than is now being used.

This would not be a more radical change than has already taken place with respect to use of straight-run and cracked motor fuels.

It may safely be assumed, however, that whatever changes take place or are demanded by circumstances, the oil industry will be prepared to supply the new demands, as it has done in the past. Prices may be higher, and there may be intervals during which temporary shortages will occur, but it is believed that sufficient raw material is in sight for the production of gasoline and lubricating oils for a long period of time.

DEPARTMENT OF COMMERCE
Washington

Material Entering Into Steel Columns Affects Strength More Than Changes in Type of Construction

Results of tests recently completed on full-sized steel columns at the Bureau of Standards, show that under present specifications differences in the physical properties of the material entering into sturdy columns produce greater variation in the column strength than all the differences in type of construction.

This work was conducted in co-operation with the American Bridge Company and the Bethlehem Steel Company. These firms furnished more than 130 tons of steel meeting specifications under which structural steel is usually purchased. This was fabricated into 69 columns having H-shaped sections and of five different types of construction. The finished columns were tested to destruction in the 10,000,000 pound testing machine of the Bureau. Likewise, over 1,000 test specimens were cut from the columns and subjected to chemical analyses and physical tests to determine as accurately as possible the properties of the steel from which the columns were made. All of the material met the specifications under which it was furnished, but differed greatly in tensile yield point.

Although much work has already been done on columns, the subject of column strength and method of design, especially in large sizes, is still a matter for so much discussion that the additional data which these tests have furnished will be of great value to engineers.

This work is fully described in Technologic Paper No. 328, copies of which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 40 cents each.

Research Saves Motorists Millions

Probably $100,000,000 a year is saved by the public on gasoline alone as the result of the co-operative fuel research that has been carried on for several years, according to Dr. H. C. Dickinson, of the Bureau of Standards, who gave a brief review at the recent annual meeting of the Society of Automotive Engineers in Detroit of the work that has been done.

A billion more gallons of fuel that is usable in automotive engines is now available from the same quantity of crude oil than was formerly available. This is due to determining by tests the properties and grades of gasoline suitable for internal combustion engines and to modifications of engines so that they will operate better on the kinds of motor fuel that can be obtained in larger quantity.

The extra gasoline thus usable is worth $150,000,000 a year, and has kept the price of motor fuel from increasing materially, notwithstanding consumption has increased tremendously as the number of motor vehicles in use has multiplied during the last four years.

Another huge saving to motorists, said Dr. Dickinson, has been effected through research into the causes and avoidance of contamination of lubricating oil in engine crankcases. Several hundred million gallons of oil are used annually in automotive engines, and half of this consumption can be avoided by the use of air-cleaners, oil filters and crankcase ventilators, which are now found on many new automobiles. These keep out a large percentage of dirt and dilution and remove from the oil in the crankcase most of the dirt, carbon, water and unburned gasoline that find their way into it from the cylinders past the pistons.

The co-operative fuel research was begun in 1922, when the National Automobile Chamber of Commerce and the American Petroleum Institute provided a joint fund to be administered by the Society of Automotive Engineers for research to be conducted by the U. S. Bureau of Standards. The first undertaking was to determine what grade of gasoline gives the greatest number of car miles per barrel of crude petroleum used in its production. From the results obtained it was concluded that the number of car-miles per gallon is not dependent upon the volatility of the fuel, and that the heaviest fuel that can be used is the most economical; that gasoline consumption is somewhat greater per car-mile in winter than in summer; that dilution of oil in the crankcase is greater the heavier and less volatile the fuel is, and that it is much greater in cold weather than in warm weather; and that small differences in initial volatility of the fuel have a large effect on engine starting.

Consequently, it was decided that, while economy dictates the use of as heavy a fuel as possible, a practical limit in this respect is set by the dilution of the crankcase oil and the difficulty of starting. Therefore, a careful study of dilution was conducted for nearly two years.

Tests of engine starting as affected by different fuel properties have been under way for more than a year, with a view to determining what changes in fuel will be needed to give the same starting ability in cold weather as in warm weather. The results show how an engine design can be modified to improve starting, and what fuel characteristics are required for easy starting at any engine temperature. Fuels that differ only a little from others that give only twenty starts per gallon at 32 deg. Fahr. will give five times as many starts at the same temperature.

The public is already getting considerable benefit from this work, through avoidance of higher gasoline prices, lower oil consumption, longer engine life, and increased engine power resulting from higher engine compression. These benefits will grow as the knowledge gained is applied to the designing of engines and the production of fuel and lubricants. An even more important result of the research, however, has been the bringing together of the automotive and oil industries in a common study to adapt the engines and the fuels and oils to each other to give the most economical and generally satisfactory operation of motor vehicles.

DEPARTMENT OF THE INTERIOR

Topographic Instructions of the Geological Survey

The great topographic map of the United States is less than half completed, notwithstanding that the job has been in progress for a generation. This is easily understood, however, when it is explained that the high order of accuracy and great refinement required for this map necessitate field surveys costing anywhere from $25 to $75 per square mile, and that the map when completed, if assembled into one sheet, would cover considerably more than an acre of ground. This topographic mapping is one of the steady, year after year, jobs of the Geological Survey, and in connection with the work at this time, four parts of a bulletin entitled, "Topographic Instructions on the Geological Survey" have just been issued by the Interior Department—Parts A, B, C, and D, Bulletin 788.

Part A treats of administrative matters only and is of principal interest to officers and employees of the topographic branch of the Geological Survey.

Parts B, C, and D describe the methods adopted by the Geological Survey, after its 40 years' experience, as those best suited for obtaining accurate control for topographic maps on any scale.

Part B, which relates to triangulation, gives forms and examples for keeping field notes and for the computation of final geographic position: each step in the process is explained at length, so that, as a prefatory note states, the need for personal instruction shall be reduced to a minimum. The Geological Survey's work in triangulation has a limiting error of 1 part in 5,000 of computed distances.

Part C describes in great detail the most approved methods for running traverse lines and computing map positions. Under present conditions of field work the Geological Survey covers greater areas by traverse control than by triangulation. Directions for determining true azimuths from observations on the sun, or on Polaris, are given in such detail that any engineer who will follow them can make the observation and compute the azimuths without difficulty. It is hoped that with these aids and with the annual tables of positions of the sun and of Polaris, which the Geological Survey is always glad to supply on request, highway, railway, and other field surveyors generally will determine and report true azimuths for all surveyed lines instead of the very unreliable compass bearings. Had true bearings been reported for such lines during the last 25 years the Geological Survey could have used them for map control and thereby have saved many thousands of dollars in the mapping of the United States.

Part D covers leveling, a branch of the topographic work in which accuracy is highly essential. There are now more than 75,000 metal bench marks placed by the Geological Survey in all parts of the United States, Hawaii, and Alaska for which elevations above mean sea level have been determined. These bench marks are used extensively not only by Government engineers but also by other engineers as datum points for highway and railway surveys and for other public or private works. The instructions in Part D are the result of years of experience in spirit leveling. They describe methods of work if followed strictly are as nearly "fool proof" as human endeavor can expect. The spirit leveling as carried on by the Survey can not be classed as "precise," but it is of a much higher grade than that done by engineers of public works generally. The allowable limit of error for Geological Survey lines is 0.05 foot multiplied by the square root of the length of the line in miles. For a 10-mile line the permissible error would be less than 2 inches; for a 50-mile line, 4¼ inches. Bulletin 788-D illustrates the types of lettered metal marks used and tells how they are to be set. It prescribes the size and shape for the concrete piers and the proportions of cement, sand, and stone to use in making them. Eventually the elevation to the nearest foot will be stamped on each standard bench mark, but until this is done field engineers are advised to apply to the office of the Geoolgical Survey for the latest determinations. The book illustrates the instruments used and tells how to adjust them and to make simple repairs—for example, how to insert new cross wires or to replace broken level vials. It is intended that every important item necessary to bring successful results may be found in the 44 pages of this bulletin.

NEW BOOKS

BOOK REVIEWS

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ENGINEERS AND ENGINEERING,
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This Believing World—By Lewis Browne. 343 pages, 6x9. Index, Bibliography. $3.50.

"This Believing World" is a history of religions written in a clear, easily understood, and readable style—in reality much less a history than an absorbing story. The author first speculates on the beginning of faith in ancient times and then, taking the outstanding beliefs of the world, he clearly outlines the fundamental tenets of each, tracing its growth and its influence on mankind. This he has succeeded in doing without falling back on the technical phrases which abound in many works on religion. A devout Churchman may look askance at some of the author's statements dealing with Christ's origin and may perhaps feel that it is treated in too matter of fact and casual a fashion, but he can not overlook the fact that the book has made him think.

While of necessity this book can treat so great a subject in only a general way, it presents to the reader, nevertheless, enough detail to make him feel that he has learned much that is worth while and that his outlook has been broadened. Above all, he is in a position to think intelligently about his own religion and to see it in the light of the religions of his fellow men, past and present.

J. B. K., Jr.

Switching Equipment for Power Control—By Stephen Q. Hayes, General Engineer, Westinghouse Electric & Manufacturing Co. 2nd edition. 556 pages, 6x9, 279 illustrations. $5.00.

The new second edition of a book that represents the best up-to-date practice in America and Europe of modern switchboards and switching equipment. In addition to furnishing descriptions of switching apparatus, main connections, maximum security and flexibility with minimum outlay, switchboard panels, control desks, location of breakers, insulation, structures, plant arrangement, etc., the book covers the most recent developments in steel-clad switch gear and metal-clad compound-filled switchgear, automatic control, induction regulators, ratio adjusters, etc., etc.

Diesel Engines—By David L. Jones. 565 pages, 341 illustrations; 6x9. $5.

It explains the operation, repair and maintenance of the Diesel engine, their troubles and adjustments, indicator cards and engine testing, fuel and lubricating oils, etc. Today, the modern Diesel engine is being used extensively on shore and on ships. Engines of as large as 16,000 brake horse-power are now being built. In the last five years the number of motorships has been almost tripled and the world's motorship construction has grown to about 60 per cent of the steamship construction. The book is of special value to operating engineers and students of mechanical engineering.

Waterworks Handbook—By A. D. Flinn, Secretary, United Engineering Societies; formerly Deputy Chief Engineer, N. Y. Board of Water Supply. R. S. Weston, Consulting Sanitary Engineer, formerly Assoc. Professor of Public Health Engineering, Mass. Institute of Technology, and C. L. Bogert, Consulting Engineer, formerly Asst. Engineer, New York Board of Water Supply. New Third Ed. 871 pages, 6x9; 338 illustrations. $7.

A thorough revision of the standard handbook of waterworks information, the book is packed with essential tables, formulae and reference data on waterworks engineering. Recent developments and latest methods are thoroughly described.

Hydro-Electric Handbook—By William P. Creager and Joel D. Justin, and a staff of nine specialists. 897 pages; 494 illustrations. Flexible binding. $8.

The book is a complete working treatise on current practice. It represents the work of a staff of 11 well-known specialists. It contains much data hereto unavailable in any book. The book is unusually replete with valuable diagrams, tables, charts and other illustrations.

In a field where practice changes rapidly this book is the last word on latest developments and approved modern methods. Every phase of the subject is covered from the time the project is a dream in the mind of the promoter to the operation of the completed plant.

Movable Bridges—By Otis Ellis Hovey, B. S., C. E. Assistant Chief Engineer, American Bridge Company. In 2 volumes. Illustrated. $6.

Volume 1, Superstructure, is devoted mainly to a discussion of the structural portion of all types of movable bridges, with some description of the machinery that supports the structure of swing bridges.

Volume 2, Machinery, treats exhaustively the design of heavy slow moving machinery. In its scope it is a veritable handbook and should prove of interest to all who have occasion at any time to design movable bridge machinery, and similar machines, such as hoists, derricks, cranes, dredges, steam shovels and the like.

Highway Administration & Finance—By Thomas R. Agg, Professor of Highway Engineering, Iowa State College, and John E. Brindley, Professor of Economics, Iowa State College. 382 pages, 6x9. $4.

This book offers a concise and authoritative presentation of the management and economic phases of highway engineering. It covers the different functions of the highway department in securing essential legislative and financial requirements and particularly in the organization and supervision of the department's staff and its work.

The book will be of special interest to highway engineers, students of transportation and to public officials who must deal with highway transportation problems.

Practical Oil Geology, New Fourth Edition—By Dorsey Hager, Petroleum Geologist and Engineer. 309 pages, 5x8 Illustrated. $3.00.

A thorough revision of this standard work on the application of geology to oil field problems. The author has revised and corrected the book throughout, and has introduced new facts and theories developed in the past eight years.

Principles of Electric Motors and Control—By Gordon Fox, Electrical Engineer, Freyn, Brassert & Co. 492 pages, 5½x8, illustrated. $3.50.

How to use motors and controllers. The first practical book on motors and controllers in actual operation. Real "how and why" data on the proper choice and use of electric motor and control equipment.

Electric Power Stations—By L. W. W. Morrow, Managing Editor, Electrical World. 326 pages, 6x9; 177 illustrations. $4.

A sound discussion of fundamental principles, of production, transmission, and distribution of electrical energy on a large scale in an economical manner. The book covers such topics as plant sites and their layout, coal oil and gas—their use in electric power stations, steam, auxiliary energy supply, boiler rooms, turbines, electrical equipment, switching, etc. Throughout the book emphasis is placed upon principles underlying the selection of proper equipment for specific conditions and upon the methods of utilizing this equipment to best advantage.

Street Traffic Control—By Miller McClintock. Assistant Professor of Municipal Government, University of California, Southern Branch, and Consultant to the Los Angeles Traffic Commission. 233 pages, 6x9, 25 illustrations. $3.00.

This book analyzes the causes of existing street traffic difficulties, summarizes the experiences of the larger American cities and presents the conclusions of the foremost practical street traffic experts.

Water Purification—By Joseph W. Ellms. 485 pages, 6x9, 149 illustrations. $5.00.

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Tragedy of Waste—By Stuart Chase. Cloth. $1.50.

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ENGINEERS & ENGINEERING

MAY, 1927

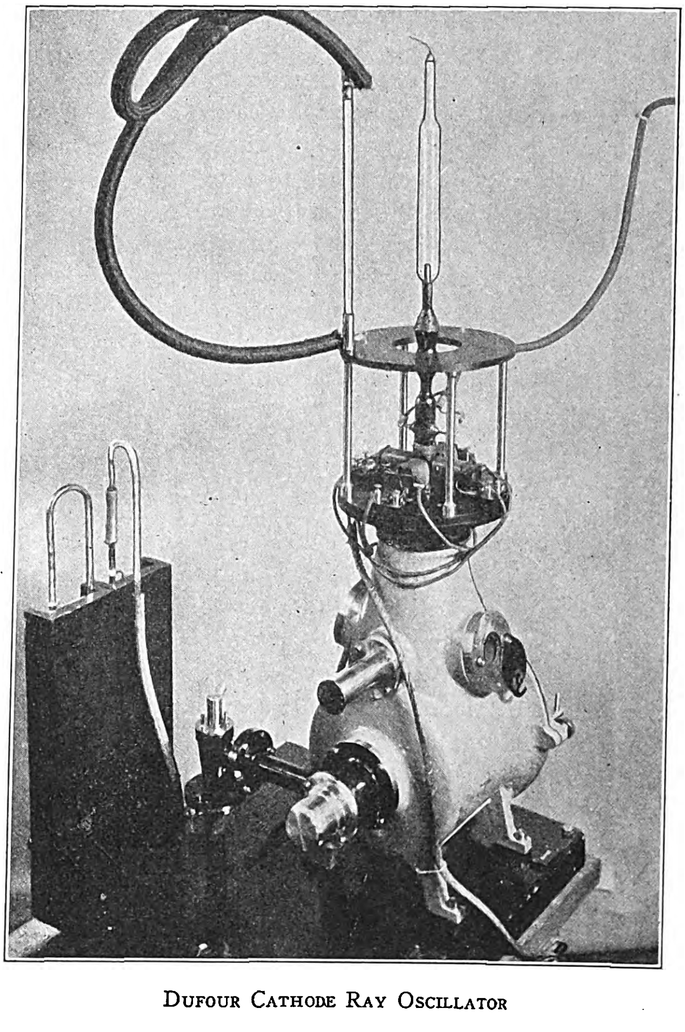
Vol. XLIV FOUNDED 1879 No. 5

Measuring Millionths of a Second

IT IS known that time as well as voltage stress is necessary to break down insulation and the breakdown is thought to be a cumulative process to some extent. Insulation which will withstand a large over-voltage applied for a very short time may break down after a number of such applications, or if the voltage is applied for a longer time. Consequently, in designing insulation to withstand high voltage impulses such as are caused by lightning and switching surges and in designing lightning arresters, it is important to be able to measure the time element of the surge to be encountered as well as its magnitude.

The time involved is of the order of a few micro-seconds (millionths of a second). The ordinary oscillograph, which furnishes a voltage time curve in rectangular co-ordinates, would have to be operated at a speed of practically one mile per second in order to make 1/16″ on the time scale equal one micro-second. Moreover, the mechanical inertia of the electrical element would so distort the recorded voltage as to completely vitiate the results even if the film could be operated so fast.

It has been found possible, however, to so modify a very old form of apparatus—the Braun tube—as to give results quite similar to those of an ordinary oscillograph without these mechanical limitations. The Braun tube consists of two electrodes several inches apart in a vacuum tube. One electrode—the cathode—is connected to the negative terminal of a high voltage direct current source and the other, or anode, to the positive terminal and usually also to ground. When the voltage is sufficiently high a stream of electrons flows from the cathode to the anode. If a small hole is provided in the center of the anode, some of the electrons will pass through, and upon striking a fluorescent screen will produce a visible spot. Since the stream of electrons is in effect a current of electricity, a magnetic field will cause a transverse deflection of the beam, and also a charged plate will attract or repel it, since it is made up of minute charges of electricity. If both the electro-magnetic and electrostatic fields act simultaneously and are suitably arranged, the beam may be made to trace figures which may be voltage-time curves if one of the deflecting systems is given a variation which is a known function of the time and the voltage to be observed is impressed on the other, or the curve may be a voltage-current function. Although the stream of electrons provides the desired indicating system which is free from mechanical inertia, there is one very definite limitation to this form of the device. The spot produced on the fluorescent screen is not very bright, and unless the phenomenon to be observed is very slow the eye



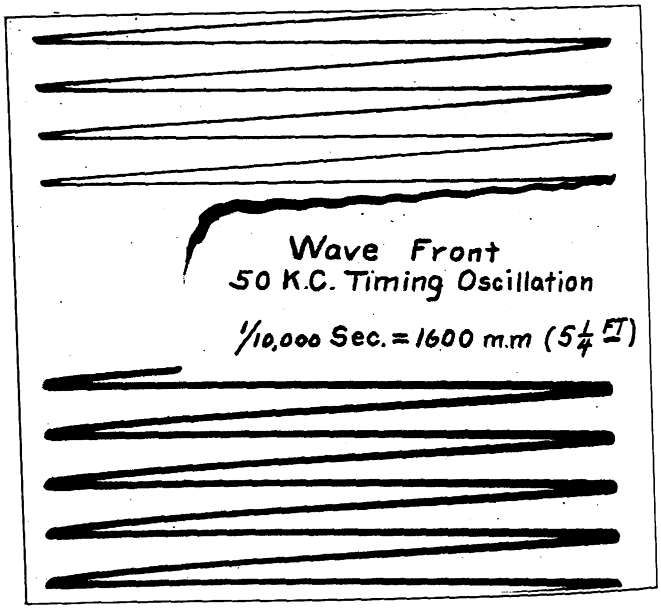
DUFOUR CATHODE RAY OSCILLATOR

is not able to follow it and a photographic film is not affected. However, if the phenomenon is or can be made recurrent, this limitation is avoided, but unfortunately this is not often the case.

In 1914, Alexander Dufour, of Paris, described an improvement which very largely removed this restriction. He placed a photographic film inside the vacuum chamber in such a manner that the electron stream impinged directly on the film. Since the electron stream will itself affect the film, the photographic obstacle to the study of high speed transcients was removed, but the mechanical problem of conveniently getting the films in and out of the vacuum chamber remained to be solved. After the war, the laboratories of the General Electric Company, at Pittsfield, undertook the further development of the Braun tube following Dufour's idea and have produced a fairly satisfying form for laboratory use.

The essential element of this latest development consists in the provision of a magazine form of film holder with suitable controls so that several exposures can be made before it is necessary to open up the apparatus. As shown in the photograph, the apparatus consists of an upper tubular portion of glass, containing the electrodes and the plates for the electrostatic deflection and having outside it, near the bottom, two pairs of coils for producing the electromagnetic deflection. Joined to this glass portion is a metal case which contains a cylinder on which may be mounted several films. This case is closed by a gas-tight cover and may be evacuated. Several rods passing through stuffing boxes provide means by which the films may be brought in turn into position for exposure, and also enable a fluorescent screen to be interposed for direct viewing.

The operation may be visualized by comparing the stream of electrons to a stream of water from a hose directed against a vertical wall. If the nozzle is deflected by the operator, the wetted path on the wall is a record of the motion of the nozzle. The two pairs of coils and the pair of plates provide the necessary means of controlling the electron stream. If a transient current which increases uniformly is passed through one set of coils the pencil of rays will move or sweep uniformly across the film and if an alternating current of high and known frequency is passed through the other pair of coils at the same time a sine wave will be traced. The distance measured along the sine wave is a measure of the time, but it should be noted that the scale of time is not uniform. Now, if the voltage transient to be observed is impressed on the plates which are so placed as to cause a deflection in the same direction as that produced by the first or sweeping coils, the two deflections compound to give a record of the transient, as shown on the accompanying oscillogram. The values of the voltage and of the time are not given directly by the coordinates of the figure except approximately, but the true values may be easily derived from them by calculations based on the sweeping velocity and the frequency of the alternating field. Since this velocity and the frequency may be made very large without encountering any great difficulties, transients involving very short times may be observed. In the figure shown one micro-second is measured by a distance of approximately 16 m.m., or about ⅝ inch near the center line of the figure. There are also other ways in which the apparatus may be used, the particular method being determined by the quantity to be observed, the time interval to be measured, etc.



OSCILLOGRAMS AT HIGH FREQUENCIES

EXAMPLE OF WAVES FROM LIGHTNING GENERATOR. USING BOTH SETS OF DEFLECTING COILS TO DRAW OUT TIMING WAVE

Since the entire phenomenon occurs in a very short time, it is necessary to make particular provision that it shall occur while the sweeping current is passing the stream across the film. A suitable switching device has been developed which controls all of the operations in proper sequence, including the application of the high voltage to the main electrodes of the tube.

C. W. BATES.

Molding Rubber With Electricity[*]

A New Electrolytic Process

MAN has long used rubber to keep electricity where it belongs. Recently some research chemists have been showing how to use electricity to put rubber where man would like to have it. Incidentally, much power-consuming, cumbersome equipment for forming certain kinds of rubber goods to prepare them for vulcanization appears to be doomed to scrap-heaps and some disagreeable work places will be transformed. Patient scientific research, utilizing modern knowledge of the way matter is put together, has again been richly rewarded. As has occurred more than once, independent workers almost simultaneously made practically identical discoveries. Again research is revolutionizing an art; rather, a new art is being built which will in part supplant old methods and in part create new satisfactions for human needs.

Better methods have long been sought for manufacturing rubber goods from the latex, or sap, of rubber trees. Rubber is not soluble in water, but latex and some other forms of pure and compounded rubber can be suspended in water by dispersing them into very minute globules. These "suspensions" or "dispersions" for some purposes resemble a solution, although in other respects quite different. In water dispersions the globules of rubber carry negative charges of electricity; consequently, when a current is passed through them the minute bits of rubber go to the positive pole, or anode. Some searchers for new methods gave attention to this knowledge.

In 1922, S. E. Sheppard and L. W. Eberlin, working in a laboratory of the Eastman Kodak Company, at Rochester, New York, and Paul Klein, A. Szegvari and a large staff in Budapest, Hungary, found independently that pure and compounded rubber could be electrolytically deposited from water dispersions onto metal or ceramic molds, in a way somewhat like electro-plating with metals. The former group was trying to cover metals with adhering coats of rubber deposited from water dispersions, and the latter to make rubber goods directly from latex.

Each investigator was practically interested in improvement of the quality of rubber goods. They knew that when the solid dried crude rubber is worked upon a mixing mill in the rubber factory, the rubber substance was altered, depolymerized, as the chemist says, and thereby became softer and weaker. They knew that the less rubber was heated or worked, the better was its quality. They also knew that research of chemists in recent years had shown how vulcanization may be carried on at lower temperatures than formerly and the necessary sulphur combined with rubber with minimum of loss of quality. Certain substances known as accelerators possess the property of permitting vulcanization to be accomplished at relatively low temperatures. However, if these accelerators were incorporated on the usual mixing mill, the temperatures would be sufficiently high to cause vulcanization during mixing and spoil the goods.

These men conceived the plan of so depositing rubber on forms, from latex, that the rubber particle itself was not altered and made the astonishing discovery that electro deposited rubber had the highest quality ever observed. Many were the problems to be solved before this was made practical. It was necessary to incorporate other substances to be deposited simultaneously on the anode, such as sulphur, zinc oxide and carbon black. These latter two substances are necessary in rubber goods to give toughness. A long investigation was carried out to find means to disperse them in water, mixed with the latex particles, without coagulating the latex. A noteworthy achievement, which has made the Anode process possible, has been the means by which these rubber layers may be free from bubbles, for when an electric current is passed through a solution, bubbles of gas are formed on anode and cathode. So they hit upon the scheme of surrounding the anode with a porus clay diaphragm. The anode is therefore immersed in electrolyte inside a porus clay cell or dish and the rubber particles together with those of zinc oxide, sulphur, etc., are deposited upon this porus so-called Anode diaphragm. Thus the rubber as it collects forms a continuous, homogeneous, tough covering of uniform thickness. Any thickness up to an inch or more is practicable. Rubber thus formed is stronger than rubber prepared by the old methods, and is free from gas or air holes. Therefore it is permissible to use less thickness for some purposes.

Industrial development is already well advanced. Continuous, automatic production of certain kinds of articles is feasible. Manufacture of inner tubes for automobile tires is the most important application, if quantity be the criterion. Bathing caps, stationer's elastic bands, tobacco pouches and hot-water bottles are other examples. Insulation for wires and other things electrical is another application. After being formed of desired thickness, articles have to be dried, cured and removed from the molds. The process may be operated as a continuous cycle. Drying and curing steps also differ advantageously from the old methods.

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[*] Engineering Foundation Research Narrative No. 125. Contributed by W. C. Geer, formerly Vice-President in Charge of Research and Development, The B. F. Goodrich Company, Akron, Ohio.

No high temperatures are used. For impregnating textiles the rubber can be more intimately applied to the fibres.

To commercialize the benefits of these researches a company has been incorporated with the name American Anode, Inc., based on the interests of the Eastman Kodak Company, The B. F. Goodrich Company and the British Anode Company, Inc. European and American leaders in this new field are co-operating in its development.

The Gyro's Strange Intuitions*

By ELMER A. SPERRY,
Vice-Chairman, Engineering Foundation

UNIQUE and even wonderful are certain characteristics of the gyroscope. Suppose we had a circle with one chair occupied by a gyroscope instead of mere man, and imagine he could speak to us. Let me tell you some of the interesting things that he would pipe up and say: "I know things that none of you mortals are in the least aware of. For example, I know that this chair in which I sit is moving, I can feel its direction and tell you its velocity. I am sure none of you has any intuitive sense of these things, but I know them instinctively. It is also easy for me to discern the difference between unilinear motion and circular motion, or motion around a center, no matter how remote or distant this center may be. As a matter of fact, this motion that I feel is around a very remote center —some 4,000 miles away—and if you stop to think, this involves an axis of motion. The exact direction in which this axis lies with reference to this city, this room, and even the chair in which I sit, is quite apparent to me."

The astonished circle look at each other and cannot refrain from commenting that such information is not only remarkable, but might become extremely useful. It would be of the utmost usefulness to the mariner if we could make the little gyro articulate in terms that could be universally understood, because if we only knew with a high degree of precision exactly the direction of the axis of the earth, this would at once give the precise direction of all meridians. If our point be moving, as a ship either in the water or in the air, this information could give us the exact position of our meridian at all times and places.

So it has been one of the objects of the last thirty years of my life to make the gyro articulate and to check up on him rather critically, (1) as to the exact degree of his precision, (2) as to his being perfectly understood, and (3) to safeguard him against disturbances due to the various motions of his mount. This has gone forward until the time has come when the great value of such a safeguard to accurate navigation, especially under conditions where observations are impossible, has become more and more understood.

It is comforting to know that as our little gyro goes humming on his way, this precision orientation which through his sixth sense he so freely and cheerfully dispenses, is based on a definite "field" that he employs as his energizing force, which is all pervasive and never failing. There is no place on the earth that does not revolve and there is no place where he does not feel the urge to service, except possibly at or near the actual pole on the ice cap, where he shakes his head and says, "What is the use of pointing to any one meridian for here they all are, together with the pole itself."

If anyone challenges his accuracy or value, there are some 2,000 of his brothers distributed in over one hundred fleets, largely merchant marine, that will stoutly enter instant and convincing proof, and if one wishes to push investigation still farther and comprehend the marvelous training that he has received through long aeons, coming down through the centuries with his intuitions tuned to the nth degree, I have only to call attention to the wonderful sensitiveness of his response to influences that are really infinitesimal. The precession velocity of gyros varies. Quite large stabilizing gyros for ships precess at measureably one radian; other services often require many radians. One recently manufactured for the testing laboratories of the Massachusetts Institute of Technology precesses at between 20 and 30 radians. It is well known that the ability of the gyro to respond to directional forces is proportional to the angular velocity that reaches him, expressed, say, in radians, and think of how sensitive have become his faculties when I tell you that the earth is enabled to hold him in complete thraldom, reaching him, as he does, with only 1/14,000 of a radian.

His embodiment and the devices that are employed to render his articulation completely understandable to all men is the gyro-compass, which is found by mariners to be entirely devoid of all the vagaries that obsess the magnetic compass and render it unreliable, especially on steel ships. One fundamental difficulty with the magnetic compass is that it feebly points to the constantly moving north magnetic pole, which averages some 1,800 miles down from the true pole that we have to use in all navigation.

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*Engineering Foundation Research Narrative No. 121.

The gyro compass is the prime controlling force of its many "repeaters" distributed at all navigational, radio and observation stations on a ship, as well as of course recorder. It also constitutes the directing force of "Metal Mike," which now automatically steers practically all great ships of the merchant marine, many of them having made the cruise around the world. So modern science has taught us how we may both lay out and hold our great fleets on the straightest course ever, without the hand of man, and, strange as it may seem, they are actually steered by the steady and unfailing rotation of the earth.

Photo-Electricity[*]

Current Generated by Light

By HERBERT E. IVES, Ph.D.
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FARADAY'S investigations on electromagnetism are striking examples of small beginnings. Another is the work of Heinrich Hertz. Within a few years he laid the foundations of modern radio, probably the greatest practical triumph of Maxwell's electromagnetic theory of light, and discovered the photoelectric effect, not yet of comparable practical importance, but exemplifying the inadequacy of that same theory.

Hertz produced electromagnetic waves by causing sparks to pass between separated metal electrodes in air. In 1887, he observed curious irregularities. With all electrical conditions the same the sparks would sometimes pass easily, at other times not at all. This behavior excited his curiosity; he sought for its cause, and discovered that when light was falling on the electrodes the sparks passed most easily. Ultra-violet light, such as the light from another spark, was most effective, as shown by great decrease in influence when a clear plate of glass was interposed.

Other experimenters soon found that the effect of light on a metal electrode was to make it acquire a positive charge, or lose a negative charge. Later, after J. J. Thompson had discovered the electron, it became clear that when a metal is illuminated it gives off electrons. Lenard, pupil of Hertz, who first systematically studied photo-electric effect, found a peculiar characteristic of the emitted electrons, which has kept the greatest minds in physics guessing; the number of electrons emitted was proportional to intensity of illumination, as one would expect; but the energy with which they were emitted was quite independent of the intensity of the light, depending merely on its frequency, or color. Thus, whether we get our light from an arc lamp a foot away, or from a candle a mile away, or from a star ten light years away, the electrons shoot out from the illuminated surface with the same initial energy—that is, the metal plate must be charged to the same positive potential to prevent their escape. Sir William Bragg has pictured the phenomenon as follows: Suppose a plank dropped from a ship at sea. Waves would spread outward, ever diminishing in height; another ship would intercept a minute section of the wave front; instantly a plank would be exploded from the side of this ship, and fly to the height from which the original plank fell.

To explain this extraordinary effect, Einstein formulated his first revolutionary physical theory, of **light quanta**; light consists not of electromagnetic waves in the ether of uniform intensity along their whole fronts, but of bundles of energy; the wave front is "speckled." This quantum is the same quantum of energy turning up whenever radiation and matter interact. No doubt of its reality, and of its importance in the explanation of the physical universe, although apparently irreconcilable with the wave theory supported by all the phenomena of interference and diffraction. Electromagnetic waves from Hertz's spark gaps wonderfully confirm the wave theory, while their light produces photoelectrons which act contradictorily.

Practical applications center around the development of highly sensitive photoelectric cells. Metals differ in power of emitting electrons under illumination. Best conditions are obtained by putting the metal in a glass or quartz enclosure, and controlling both the kind of atmosphere and its pressure. The more electro-positive the metal, the more photo-sensitive; so in place of zinc and copper, in the earlier studies, an alkali metal, potassium, rubidium or caesium, is used in non-reacting atmospheres—an inert gas, argon, helium, or neon—at a low pressure suitable for multiplying the photo-current by the electric conduction induced in the gas by collision of the electrons with the gas atoms.

The typical photoelectric cell is a glass bulb, with one electrode, the cathode, usually a layer of alkali metal on the inner surface, with a wire leading out through the glass, and another electrode, the anode, a loop of wire, likewise carried out. Connect these two wires through a galvonometer and let light shine into the bulb; the galvanometer will show an electric current flowing. The current starts and stops instantaneously; it is proportional to the illumination. It is quite small, but with proper instruments it may be used to measure the intensity of light from such faint objects as sixth magnitude stars.

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[*] Engineering Foundation Research Narrative No. 120.
[†] See Research Narratives 33 and 107.

In electrical transmission of pictures† photoelectric cells do exactly what is required. They transform the light and shade of a picture, as traced by a tiny beam of light, into an electric current, varying exactly with the picture values, and without lag or distortion. To be used, some means had to be found to increase the minute photoelectric currents for transmission over telephone or other lines. This has in recent years been made possible by the development of the thermionic vacuum tube.†

May we look to photoelectricity for direct conversion of the sun's radiation into electrical energy, for industrial purposes? As yet efficiency is so low as to offer no immediate promise. It is probable that utilization of the sun's radiated energy by vegetation is primarily induced by photoelectric response. We may, by advancement of knowledge of photoelectricity, master ultimately the utilization of solar radiation, though we may have to resort to the indirect method of nature.

Uses of Mica

The chief use of mica is in the electrical industries, states the United States Bureau of Mines, Department of Commerce. One very widespread and important use is in the manufacture of the transmitter button, an integral part of the modern telephone instrument. Mica is also used in the manufacture of lightning arresters, condensers, commutators, and many special types of equipment. In addition to its use for the glazing of stoves and furnace, mica is manufactured into lamp chimneys, particularly for gas and gasoline lamps. For this purpose the mica must be clear, even splitting and flexible; little domestic mica is suitable for this purpose. Ground mica is utilized in the preparation of rolled roofing; it is dusted on the roofing material before rolling, and thereby prevents sticking of the rolls. A pound of mica has great covering power because of the flat shape of the thin particles. Ground mica is also used as a decorative material on wall paper and in special paints. It is occasionally employed as a facing for concrete to simulate granite. Coarsely-ground material is used for decoration and is sold under the name of Christmas tree snow; the tonnage of material consumed in this market reaches an appreciable figure. Finely ground mica is used as a lubricant incorporated with greases, and also alone, especially as a tire powder. It is also used extensively as a rubber filler and in many other minor industries.

Very flat and sound high-grade mica was previously in great demand for diaphragm use in phonographs. During the past year the demand in this market has shown a great increase, due to competition with the radio, and to the development of new types of phonographs which do not employ mica diaphragms. There has also been a constantly decreasing demand for mica chimneys on account of the replacement of gas by electric lights. The use of mica in the manufacture of spark plugs, which at one time was of much importance, has greatly decreased since the introduction of improved spark-plug porcelains.

The sudden and surprising development of the radio industry has created a market for very large quantities of mica, particularly in the smaller sizes of sheet material suitable for the manufacture of condensers. A certain amount of diaphragm mica has also been consumed in the manufacture of head phones and loud speakers, but this does not compensate for the decreased demand in the phonograph trade.

It is anticipated that the future expansion of the electrical industries will supply a market for large quantities of sheet mica and splittings. The projected electrification of certain railroad lines and the development of the oil-electric locomotive will also demand large quantities of this mineral.

New Process for Recovery of Valuable Mica Wastes

The recovery of highly valuable mica wastes, hitherto lost in the ground mica industry, due to incomplete settling of fine materials in the wet grinding process, is promised as the result of experiments conducted by the United States Bureau of Mines, Department of Commerce, at its Non-Metallic Minerals Experiment Station, New Brunswick, N. J. The solution of the problem is indicated in the application of electrolytes as flocculating reagents. As finely-ground mica is a high-priced product, attaining a value of $100 to $120 per ton, the losses from this source attain proportions that seem to demand a remedy.

In the mining of mica, a considerable tonnage of material is produced which is so damaged by rumpling, folding, the presence of impurities and lack of size, that it cannot be manufactured into sheet goods. In the early days of the mica industry this material was considered worthless and no effort was made to recover it. The discovery that ground mica produced from this scrap is of value to many industries has resulted in the profitable disposal of most of such material now being produced as a by-product at the mines. The supply of scrap mica from this source is augmented by the trimmings produced in the manufacture of sheets; by mica not suitable for sheet goods produced as a by-product in the operation of feldspar mines and clay pits; and by production from mines which are operated for scrap alone. This utilization of scrap mica has been a benefit to many mines, as it has afforded a source of additional revenue sufficient to justify the operation of properties which could not produce sheet mica alone in quantity having a value great enough to pay for the cost of production. The market absorbs from 5,000 to 9,000 tons of ground mica per year.

Strengthening Highway and City Street Foundations to Meet the Increase in Motor-Bus and Truck Traffic

(Continued from April issue, page 101)

DISCUSSION

MR. ADLER: I think it would be very hard in this general section of the country, to select three towns where there are as great variations in sub-grade, climatic and other conditions as between Pittsburgh, Philadelphia and New York, with the possible exception of seashore points. And with the general idea of giving all the different aspects of the situation, I am going to ask Colonel R. Keith Compton, Director of Public Works, of Richmond, Va., and formerly consulting engineer of the Paving Commission of Baltimore, to give a picture of conditions in the general locality of Maryland and Virginia, as he is familiar with them.

COLONEL COMPTON: Since I have transferred my allegiance from a city of 800,000 people, where I was Paving Engineer, to one of 200,000 people, where my activities extend all the way from building sewers and bridges to burying people, I have somewhat changed my mind about a few things. I used to think, when I was a paving engineer, responsible for the installation of new paving, that the utility man who came along and wanted to tear up that pavement ought to be shot, but I find myself now in the position where I frequently have to request myself to be allowed to open a pavement, and for that reason I am looking on that side of life a little bit differently. Washington was long noted for its excellent pavements and has continued to be noted for that excellence up until the last few years when Congress has failed to appropriate sufficient money to keep up the pavements. If you will bear with me for a minute, I would like to take up with you, first my experience in Baltimore City, extending from 1911 to 1924, where we laid some six or seven million yards of pavement, including bituminous, brick, granite, block, wood block, concrete. Of course, after the war, we had to confine ourselves to practically sheet asphalt and granite block, owing to the exceedingly high cost of other pavements, but during those years some concrete was used. Baltimore is a very old city, and we started that vast paving program in 1911 with five million yards of cobblestone in the city. To put that before you in a more concrete form it meant if you were to divide it into a roadway eighteen feet wide, it would extend over a distance of some five hundred miles. A great many people thought that all you had to do was to put on top of cobblestones, a binder, and then your wearing surface, but when you stop to consider that Baltimore at that time was building its sewerage system, that its water system was very old and worn out and had to be reinforced, that the gas company had to reinforce many of its main supplies, and the telephone company had a few other things to do, there was not very much left of a cobblestone street after they got through with it. My experience has been that in attempting to resurface any sort of an old stone pavement, such as cobble or granite block, with asphalt paving, if that pavement is once disturbed, no human agency can put it back as solidly as it was before. In attempting to repave cobble streets in Baltimore, we faced an entirely different situation than we thought, because when the utility companies got through, the last state of that pavement was worse than the first. We did finally attempt to do some re-surfacing, and laid some three or four hundred thousand yards of resurfacing on cobblestone streets. Where the street was torn up promiscuously, we simply took cobbles up, crushed them, and used them for base, reinforced the trenches, and proceeded. Our cost for resurfacing was $1.50 a yard, and I think the price of standard sheet asphalt on a concrete base was $1.75, so you see there was practically very little saving. However, those payments are in use today, and I am told that very little if any repairs have been required.

Some years ago I sent a questionnaire to some 700 cities in the United States and Canada, and received 300 or 400 replies. I became fully convinced, after analyzing those replies that the standard mix in this country was 1-3-6, and the paving base 6″ in thickness. In all of my experience, I have never known a 6″ concrete base to fail, when on a reasonably good sub-grade. I have never known a well laid 4″ concrete base to fail, where laid on a good sub-grade on a light traffic street, and I think after all, it finally works itself down to this proposition, that there are three subjects which you must consider—sub-grade, and included in sub-grade, of course, is the condition of the sub-grade, even though it may have been good at first, as it may have been left in poor condition by carelessness in back-filling trenches; traffic, and under that heading the engineer must be guided by the volume and extent of the traffic, in accordance with his own best judgment, coupled with any traffic counts which he may be able to obtain; and then comes financing, and under the head of financing, I will simply say this, that an engineer must use common sense. You know there was an old saying—an engineer is a man who can do something for a dollar that any damned fool could do for $2.00. When you come down to financing, I can see no reason for putting a $3.50 or a $4.00 pavement on a street where a $1.50 pavement will give just as good service. Only this past year, in Richmond, we resurfaced gravel, we resurfaced brick, and resurfaced second-class granite block, with Bessonite, which was invented by Major Besson, when he was one of the District Commissioners of Washington. It consists of coarsely graded sand with an excess of dust, and then the addition of the A. C. as a wearing course which can be laid without binder. We used it in Richmond this year on those original surfaces which I have just described. It was laid as low as $1.40 a yard, an average thickness of two inches, and in other instances, where we had to put in an excess thickness, it ran up to $1.65 a yard.

We reinforce our trenches to some extent, but I think we are largely fooling ourselves. I have become convinced that unless the sub-grade is in proper shape, where it has been disturbed, or where it has not been disturbed, that no amount of reinforcing will save it, if the ground underneath the base goes down; even if it is reinforced it is bound to blow up, no matter what your thickness is. I used to think that I would make a pavement as difficult as possible for the fellow to tear it up. Now, after having to tear up a few myself, I have come to the conclusion that it is better not to have so much difficulty about it.

I have reached the conclusion that we are fooling ourselves in placing reinforcement. I think we must depend on honest to God concrete, whether it is 4″ thick or 6″ thick. We must see that proper sands are used by the contractors, that the proper aggregates are used. More concrete is ruined by using an excess amount of water than anything else. And I know of no pavements that have failed through deliberately poor work on the part of the contractor or inspector. I think where failure has occurred in original work it was due to carelessness on the part of both. I think most contractors are honest; I know most inspectors are honest. I find that it is good policy to call an inspector's meeting at least once a month or once in two months, because an inspector has a thousand and one details to attend to, and manifestly he gets rusty in his job unless he is jacked up occasionally.

I do want to impress this upon you, that no matter what opinion you may have about how work should be done, unless we get good concrete in foundations, then all our efforts have been thrown away. Do not think that any amount of reinforcement will save the situation.

MR. SYLVESTER: Colonel Compton referred in his remarks to the settlement that is bound to take place in a ditch where the sheathing, lagging and bracing is left in. Speaking for the Philadelphia Electric Company, we do not leave any sheathing or braces of any sort in any of our ditches, and I think I can speak for the other public utilities, because the matter was discussed at one of the technical committee meetings during the past three months. It might be interesting to the visiting engineers to know, as supplementing Chief Neeson's remarks, that the city ordinance in Philadelphia requires payment of no permit fee from the utilities, but they are obliged to maintain and keep in repair any openings they make for a period of five years, which, of course, the plumber is not obliged to do, but he pays his permit fee.

It is our practice in the restoration of pavement with a concrete base, where we restore them ourselves, to replace the concrete base, after mechanical tamping, in accordance with our understanding with the highway bureau, and barricade it for 48 hours, in addition to which we leave whatever surplus dirt has been taken out by the concrete gang when the concrete base was restored. We found that was necessary in order to protect the ditch. While we do not cover it with dirt specifically, we leave it there so the traffic can not run over it. We also found that the police frequently put the barricade on the sidewalk in order to make their job a little bit easier, so that we had another difficulty there. In the case of a "guaranteed" street, however, we have to give the order directly to the guarantor.

It might also be interesting to know that in Philadelphia, at least as far as the Philadelphia Electric Company is concerned, where we construct manholes in improved streets, we very recently developed a method of undercutting that permits supporting the original base of the street paving on the walls of the new manhole. The manhole is poured with concrete, and the excavation is made of the same dimensions as the inside of the manhole, and after the depth is reached, the side walls are undercut, depending upon the size of the manhole, whether it is nine or twelve inches, and then the concrete roof is poured, after the walls have been poured, so that the concrete roof is brought right up to support the original paving base, then there can be no possible chance of settlement of the original paving around the excavation made on account of the manhole. That has not only resulted in a better paving condition as far as the street was concerned, but has resulted in considerable economy in the construction of the manhole as covered by the repaving cost.

COLONEL COMPTON: There is just one point, Mr. Chairman, which I overlooked and which I would like to emphasize, and that is the extreme importance of curing concrete properly, whether it is a base to be covered up, or whether it is a concrete wearing surface. I make it a policy on bituminous work to cure the concrete by keeping it damp, or, in long periods of dry weather, keeping it covered with earth after it has its full initial set, and not allowing the bituminous top to be laid certainly under seven days, and ten days to two weeks if possible. I would rather turn light traffic over it than put my heavy roller on it too soon. In concrete wearing surfaces in Baltimore, we keep the street closed to traffic from fourteen to twenty-one days, depending on the condition of the weather and the time of the year, and we also use the curing process. You will find that if you follow that process on a concrete base, which is afterward to receive a bituminous wearing surface, you will avoid cracks to a large extent.

MR. NEESON: I would like to ask Colonel Compton if that is a general policy, and what consideration is given to the economic loss to abutting property owners, or business houses, along fronts where you might set up concrete for a period from seven to fourteen days. That is one of our difficulties.

COLONEL COMPTON: It is a hard policy to follow, but we endeavor to fight it through. It is true that we get very little co-operation from the police and get none from the general public, because the general public thinks you can build a street up in the air and let it right down all ready for service. Of course concrete wearing surface is usually laid in the outlying sections where you can keep it closed two weeks or ten days, we take advantage of that.

MR. E. E. BUTTERFIELD: Colonel Compton has spoken of the necessity of getting good concrete. The first question is, "What is good concrete?" and then, "what is 'pathological,' or abnormal concrete? And what becomes of the bad concrete if left in place?" We have had experience along those lines, which has been quite illuminating and quite surprising in some instances.

We use the core drill to check our work—not because we are alarmed, but because we had the fortune of having a politically motivated investigation which raised a question in our own minds as to what we have been getting. And since then we have drilled all our jobs systematically and have incorporated in the contract form a core drill clause, giving definite requirements as to strength, uniformity and thickness after twenty-eight days.

Mr. MacGregor spoke of the relatively slight differences of the several Boroughs. The Manhattan and Queens specifications differ essentially only in this core drill clause. We do use eight-inch bases over marsh land and on new Queens Boulevard where the traffic in a few years will probably be equal to that of Fifth Avenue. Just to give you an idea of our relation to Manhattan, Mr. MacGregor has it all over us on streets permanently paved. He has 490 miles; we have a scant 200, but we have 1,200 miles of dirt roads and we have 145 miles of old waterbound macadam. We have 108 miles of sheet asphalt, of which only 78% is on concrete, therefore permanent. Two per cent is on granite block and 27% is on old macadam. So our problems are those of both a metropolitan area and of a rural community. The area is 117 square miles in the Borough alone; that is, 37.4% of the whole city of New York, so while Mr. MacGregor has the mileage of permanently paved streets, we have the area and the new work to do.

To show you the workings of the core drill, before we had any clause in the contract, when the question was raised as to what we were getting, we drilled at random 106 jobs, and we got an average compressive strength of 1,500 to 1,700 pounds per square inch on 6" cores at 28 days. That was a 4¼" diameter, corrected for 2:1 diameter ratio. We incorporated a core drill clause in the contract requiring a compressive strength of 1,500 pounds, after 28 days, and that 75% of the cores show at least 80% of the average compressive strength required. Immediately, in the next year's work, the contractors had some kind of a reaction. They put in seven inches of base, and the average for that year was 1920 pounds on 113 jobs.

There is reasonable doubt as to the feasibility of a 1,500 requirement on a core drill on 1-3-6 base. So we revised that downward to 1,300 pounds. That was reflected immediately the next year, in 1926, with a general average of 1,648 pounds for 134 jobs, on 774 cores.

The clause is a little strenuous for the contractor, because it obligates him to accept the measurement of the core from each day's work as representative of the job, so that in the event of any litigation his hands are tied before he starts. That is part of the contract, and it has worked out very well so far.

Every now and then, we get some curious results. During the course of an investigation of one of the jobs that was criticized, being unable to obtain cores, we tried to get out slabs and saw them up into cubes. We had no saw of our own, so we sent to a marble works. The foreman said he could not saw it; it fell to pieces under the saw. We went over the chemistry of it; as nearly as we could find out chemically, it was not sufficiently off in the calcium factor to be condemned as lower than 1-3-6, and was not sufficiently high to say unqualifiedly that it was 1-3-6. Nobody would pass the pavement and nobody had nerve enough to rip it up. We went back the next year and tried to drill it, with no results. Two years later, we drilled that job from stem to stern. I figured that by that time the concrete would be shattered. Incidentally, we were able to get out on the first take of samples, two four-inch cubes. One of them broke at 500 pounds, and the other at 700. I figured that concrete of that low strength, on a heavy traffic street, at the end of two years, would be so pounded to pieces that there would not be anything left. At the end of two years and a half, we drilled the job, from one end to the other, and got a core everywhere we drilled, and the average was over 1,300 pounds.

Other freak cases are those that occurred during cold weather. We have a clause in the contract that no concrete is to be laid when the temperature is at or below 32°F. If they lay it at 32°, usually you can figure it will be twenty degrees at night, and sometimes lower. We had a couple of cases where the work was done between November 5 and 12, and between November 15 and 29, and in that period we had drops in temperature as low as seven degrees. In one case, the concrete was subject to freezing before it was five days old, and in the other case during the process of laying. We drilled the first job on January 5, after it was just about twenty-eight days old. Of five cores, the average compressive strength was 933 pounds, varying from 528 to 1,426. I thought then that this job had been frozen, and nothing further would ever happen to it except that it would probably be pounded to pieces, and that would be all there was to it. So at the insistence of some of the engineers, and particularly the contractor, we drilled again a month later, and it showed a compressive strength of 1,047 pounds—showing a tendency to gain after severe freezing. This concrete was actually frozen. Some of my men went over the job while the foundation was in, before it was covered, and found it covered with ice—ice on the sides, and ice as far as you could see. On February 7, we drilled eight cores. We set four of them aside. The compressive strength, as I said, was 1,047 pounds—on the others. The four that were set aside were allowed to dry out at room temperature. The result from those cores, from the same site, the same location, dried out, six days at room temperature, was 1,481 pounds, showing that that concrete, although frozen, has the power of standing up if proper curing conditions could be obtained.

Now, are those results freaks? Are they conditions due to variations in workmanship and to conditions in the field that you would never strike in the laboratory? They are not. We were impressed and annoyed at the variation in our work. Even though we get our average, and even though 75% of the cores have more than 80% of the compressive strength required, every now and then you get one around 500 or 600 pounds, and the question is, how are those variations to be avoided? Can they be avoided in field conditions? The size of the test specimen, as we all know, has a great deal to do with the compressive strength you obtain. In fact, you do not get a true figure for compressive strength until you get up to twelve to eighteen times the diameter. Such specimens, of course, are entirely out of the question, and the correction factor becomes increasingly greater as you go down to smaller lengths.

To try to get some notion of what the relation between height and diameter in cubes and cylinders was, we made up three large slabs of laboratory mixed concrete. The three slabs were of the same mix, so close that the unit weight of the concrete was, in the three slabs, 158, 155, 155. The solidity ratio, .86, .82, .82. The water ratio in all cases was 1.25. We cut them up into four inch cubes, 3"x6" prisms, one slab, 6" cubes from another slab, 4"x8" prisms from the same slab;—the next slab, 8" cubes, and some 5"x10". Then we made from the last batch standard 6"x12" cylinders. In that range of sizes, from concrete cured under the same conditions, mixed in the laboratory, sawed specimens, compared with A. S. T. M. cylinders, we got from a 4" cube, a maximum of 3,596 pounds, 1-3-6 concrete, down to 1,234 pounds from rectangular specimens. On the A. S. T. M. cylinders, of the same batch, average compressive strength of 1,180 pounds with a water ratio of 1.25. So you can see the enormous variations you may expect in the concrete foundation, where you can not control your temperatures, or your conditions of curing as you can in the laboratory. If we can not do better than that in the laboratory, I think we should be reasonably satisfied with what we are getting in the way of uniformity of base work.

It is well to know what we are getting, before we consider any radical changes in design. Bear in mind that I do not base the durability of the concrete base on the compressive strength—it is simply the most convenient and easiest way we have of trying to obtain uniformity. But unless the results become more erratic, and as long as we are getting results such as these, with frozen concrete, and in some of the other cases I have cited, I am satisfied that we are getting good work with our six inches of 1-3-6.

MR. TEBBS: I just wanted to add a word here from our experience. We have drilled cores from our pavements and moulded cores for comparison, and of course that requires that specimens be transported to laboratories for testing. We have, in the last year or so resorted to the moulding of plain beams on the job, allowing them to cure under the same curing conditions, and these beams are 6x8x42 inches long, and we make a very simple machine in which they are tested as a cantilever by attaching to a solid base and allowing the end to stick out, and attaching a device there on which you can load up increments of load—or some people use a Toledo scale and get a transverse test which is a good comparative test (we think better than compression), and we find much greater uniformity than we ever got with compression. We can get them aged exactly right under field conditions, and test them right in the field. Such a transverse testing machine is very cheap, very simple, and can be used to good advantage by anybody that doesn't find it possible to use compression testing.

MR. ADLER: I would like Mr. Butterfield to clarify one or two statements. In bringing out the fact that we must expect some little variation in the field in our concrete, you dwelt on the fact that in laboratory tests of various forms of specimens which were taken either by sawing or otherwise from large slabs, all of which were either cubical or rectangular in shape, you found a variation of 3,596 pounds as a maximum down to 1,234 pounds per square inch as a minimum, and these figures, as I understand, are in contrast with an average strength of 1,180 pounds per square inch obtained on 6x12-inch cylinders on concrete mould at the same time. Now are we to understand that you mean that this great variation, from 3,596 to 1,234 is due entirely to uncontrollable factors in the making and testing of that concrete? Or was not a great deal of it admittedly due to the difference in the form of the specimens, some of which were comparatively slender, that is, high, in respect to their cross section, while others were short, squatty cubes, four inches in depth?—and is the present science of concrete testing far enough along that we are able to evaluate to a reasonable extent the difference which we may expect due to form of specimen? In other words, I want to clear up in the minds of the audience whether you really mean that against cylindrical specimens of 1,180 pounds, we will say, the laboratory man cannot do any better than to find uncontrollable variations up to 3,569 pounds.

MR. BUTTERFIELD: You are perfectly right on that, Mr. Adler. The purpose of those tests was to see if we could get any rational curve for the correction to a uniform height-diameter ratio. The high figure is on a four-inch cube which invariably gives a higher strength. For instance, our four-inch cubes on a 1-3-6 base in the field gives us an average of 2,500 pounds, whereas a 4 1/3 by a 6″ core gives us an average from 1,300 to 1,500 pounds, and not only that, but the low figure is where the concrete is broken in a direction at right angles to the direction of compaction. It is much stronger in the direction of compaction than in the other direction, and the specimens in that whole series, tested one group in one direction and the other in another direction, bore that out. That was the purpose of the test. I simply gave you the maximum variations obtainable in a given mass of concrete, dependent, of course, more or less on the size and shape of test specimen. But I have not quite found any curve which will give us a universal interpretation of height and diameter ratio, because the value with a cube, or a cylinder, varies with the area under compression, and a large part of that value in small specimens is due not to the compressive strength of the concrete, but to the friction between the top of the specimen and the head of the machine before the concrete begins to give.

MR. ADLER: The other question I have in mind —when you incorporated in your specifications the requirement first of 1,500 pounds per square inch minimum of compression, and more recently 1,300 pounds, —are those figures applicable to the direct results that you get on the specimens obtained from the base, or are they corrected in terms of 6x12 cylinders?

MR. BUTTERFIELD: They are corrected for 6x12 cylinders. The height-diameter ratio is usually 1.4. The simplest way, I think, is to give the exact wording of the contract.

This is Clause I in the contract form, which holds for all pavements, sheet asphalt, etc., with concrete bases. "The Borough reserves the right to drill cores at intervals of 300 feet, starting from any point in the course of the work, or at least one core from each day's work. The contractor agrees to accept these cores as representative of the work, and to accept the measurements of such cores as representing the thickness of the entire pavement. The concrete shall have a compressive strength equivalent to 1,300 pounds per square inch at 28 days on standard cylinders with the height-diameter ratio of 2. The contractor shall be considered to have met the requirements of the specifications when, the average of all material is equal or better than the requirement. At least 75% of the test specimens shall show a strength greater than 80% of the requirement. Failing to meet these requirements, the concrete shall be rejected. In such case, the contractor may, at his own expense, employ a recognized testing laboratory to take test samples and make representations to the Borough of Queens."

MR. NEESON: What would you say of a core taken out of the work which showed a proportion of let's say one to eleven on a 1-3-6 mix, that developed 1,650 pounds?

MR. BUTTERFIELD: That is quite possible, Mr. Neeson. We made up some 1-4-7 and some 1-5-10 and some 1-7-14 mixes, and under careful compaction and laboratory curing, I think we got as high as 600 pounds on the 1-7-14 mix, and on a 1-4-8 it was only slightly behind a 1-3-6 in average compression.

MR. KERNS (Barber Asphalt Co.): We find here in Philadelphia, as well as in a great many cities in which my company has done considerable work, that most of the failures in concrete are due to the subsoil, due either to poor drainage, or previous excavation that has not been properly tamped or back-filled. I do not know any real failure due to any other cause in any of the concrete work we have done. The enormous weight of some of the buses that are now in use has given us more trouble than any other cause which has been referred to. We have a great many cases here in Philadelphia, laid by our own company, as well as by others, that are not standing up in the outlying districts, where the soil had been disturbed just prior to the laying of the concrete foundation. The Bureau of Highways probably endeavors to use every precaution in their power to have all the trenches back-filled properly, but I am sorry to say that the same cannot be said of some other organizations. We notice that the Highway Bureau this year is asking that all ditches be machine tamped. I have not the opportunity of asking anybody connected with the Highway Bureau how they propose to ask a contractor to tamp those ditches back, which are dug by other organizations, or, whether putting a machine tamper on the surface of a street is going to get very far toward having the bottom of that ditch solidly compacted. In the soil of most cities there is considerable clay, and we may get a very closely compacted *surface*, but the bottom of that ditch is not going to receive the pressure the top will receive.

Therefore, machine tamping, unless you start at the bottom, is not going to help us much. Of course, it will, to a certain extent, but it will not entirely do away with that particular weakness. There are cases where the soil is such that some of the concrete shattering would have been eliminated, or prevented, if there was additional thickness in the concrete. The weight of the loads is too great for the thin wearing surface that is put on them in order to maintain them. That is especially noticeable on streets where new bus lines have been started. Buses have been in operation for only about two years in this city, and you can almost follow the trails that they are leaving behind them. Ordinary traffic of motors, that have a capacity limited by the State to 26,000 pounds, have made no impression at all on those same pavements. During the war, I venture to say, a great many of those trucks, while limited to 26,000 had 40,000, but the motor buses are making their marks on all of these different streets.

Outside of those I have called your attention to, I know of no real failures in the city of Philadelphia on account of lack of additional thickness in concrete.

MR. ADLER: Mr. Kerns, in referring to the problem of paving on badly ditched streets, especially ditches made by organizations or individuals not primarily interested in the life and satisfactory results to be obtained from the paving, has touched upon what seems to be one of the most important phases of the problem that we are discussing today. I also believe in spite of some of the very strong arguments and excellent reasons that have been given for the six inch base, (which it seems Mr. Kearns himself believes to be satisfactory when other conditions are satisfactory), that the city of Pittsburgh must have hoped at least to overcome the bad results of these recently ditched streets when they adopted as generally as they have a rich mixture and the thickened base of which Mr. Lyons told us.

Quality Control of Concrete for Pavements and Foundations, Including a Brief Review of the Impact Studies of the Bureau of Public Roads

By F. H. JACKSON
Engineer of Tests, Bureau of Public Roads, Washington, D. C.

THE major portion of my contribution to the very timely subject which you are considering today will be confined to a discussion of ways and means for improving the quality of concrete used in pavements and foundations. I have, however, been requested by your Chairman to preface my remarks with a brief review of the motor truck impact tests which have been under way at the Bureau of Public Roads for a number of years.

The sudden and tremendous increase in the weight and volume of motor truck traffic brought about by the great war resulted, as you will recall, in the complete failure of many pavements which had most satisfactorily served pre-war requirements. This sudden breakdown in our highway transportation system was in a sense the first warning of the dawn of a new transportation era in this country—an era in which the *weight* rather than the *speed* of the transportation unit was to become the predominating factor in determining the type and design of our truck line highways. Furthermore, there came speedily the realization that the old more or less rule-of-thumb methods of building roads which had largely persisted up to this time must give way to construction based on a rational design of the structure. This, in turn, necessitated an accurate knowledge of the amount and character of the forces produced by this new type of traffic on pavements under various conditions of subgrade support. The conspicuous absence, however, of any authoritative information which might be applied to this problem made it imperative that steps be taken to secure reliable experimental data without delay.

The research work carried out at Pittsburg, California, and on the Bates Road in Illinois, together with the impact tests of the Bureau of Public Roads at Arlington, were all instituted shortly after the war in an effort to supply this need. The two former researches have been completed with the result, as you know, of developing a cross-section design for concrete pavements entirely different from that previously employed and which is now used by 39 out of the 48 states. The impact tests at Arlington are still in progress. Much has been learned but much remains to be learned, particularly in regard to the effect of different types of tires and the roughness of the road surface on the amount of the impact force.

Those of you who may be somewhat impatient with the seemingly slow progress made in this work must remember that the Bureau was entering an absolutely virgin field of research activity. Extensive preliminary work, including the development of satisfactory measuring instruments, for determining the intensity of the impact forces, stresses in pavement slabs, etc., had to be carried out. Time does not permit any extended discussion of the various stages through which these investigations progressed up to the time when it was found possible to apply some of the results. Numerous progress reports [1] [2] [3], however, have been published from time to time and these may be referred to by any one further interested.

The impact tests of the Bureau of Public Roads have, in general, been carried out along two general lines—tests made on small pavement sections with an impact testing machine—and tests made by operating actual motor trucks over either full size experimental pavements or over our actual roads in service.

Investigations along the first line have included impact tests on two series of pavement slags 7′ square. The results of these tests have been published in detail and will not be referred to here except to list some of the outstanding conclusions which were drawn. The results in general showed (1) that a subgrade of high supporting value materially increases the resistance of rigid concrete slabs to impact, (2) that impact resistance varies neither as the depth of the slab nor as the square of the depth, but as some power less than two, (3) that plain 1:3:6 concrete offers from 60 to 80 per cent of the slab resistance of 1:1½:3 concrete, (4) that reinforcing steel if present in sufficient amount and so placed to take tensile stress adds to impact resistance, (5) that for a given percentage of steel small bars closely spaced are more effective than large bars widely spaced, (6) that under the temperature conditions obtaining at the time of these tests—up to 90° F.—there was no evidence of a cushioning of the impact by bituminous tops laid on concrete bases and (7) that a bituminous top does not add to the slab strength of the concrete base, under the temperature condition obtaining for these tests.

A word or two of comment as to the last two conclusions may be in order, because of the impression which appears to have been created that the Bureau of Public Roads considers these tests to indicate that a bituminous top adds nothing to the value of a concrete base. The writer believes that it was not the intention of the Bureau to create any such impression and will endeavor to explain why. The data upon which conclusions (6) and (7) are based are given in Table I.

TABLE I—Data on cushioning of bituminous tops.

Concrete	Plain			With 2-inch Topeka Top	
Mix	Thickness	Height of drop	Impact of 2-ton truck wheel	Height of drop	Impact of 2-ton truck wheel
Dry subgrade	Inches	Inches	Pounds	Inches	Pounds
1·1½·3	4	0.97	11,440	0.95	12,060
1·3·6	6	.54	18,300	.62	19,800
1·1½·3	6	.68	20,000	.60	24,500
1·1½·3	8	1.15	41,500	1.23	37,800
Wet subgrade					
1·1½·3	4	(1)	(1)	....	....
1·3·6	6	.48	9,200	.47	9,460
1·1½·3	6	1.06	11,600	1.18	11,330
1·3·6	8	.40	8,660	.46	8,975
1·1½·3	8	1.53	27,100	1.92	25,250

(1) Failed under static load.

This table gives the total impact forces, as measured by an accelerometer, registered by the impact machine at the appearance of the first visible crack in the base, as well as the height from which the truck wheel was dropped. It will be observed that for equal heights of fall, approximately equal impact forces were registered for both the plain concrete slabs and those with a 2-inch Topeka top. It is reasonable to suppose that if the bituminous tops had exerted any appreciable cushioning effect the impact reactions would have been considerably less than those indicated in the case of similar concrete slabs without bituminous tops. Moreover, if the addition of a bituminous top to a concrete base materially increased the slab strength of the base it is to be supposed that considerably higher impact forces would have been required to crack such a base than in the case of a similar concrete slab not so protected. It must be remembered, however, that in these impact tests the slabs were considered to have failed upon the appearance of the first visible crack. As a matter of fact, these tests show, and it was so reported, that the Topeka tops materially lessened the destructive effect of succeeding impacts, especially under good subgrade conditions. The point the writer wishes to leave with you is this. Simply because a concrete base protected with a black top cracks under the same impact force as is required to crack a similar slab not so protected is no reason for assuming that the black top does not perform a useful function. The cracking of a concrete base under a black top does not constitute failure any more than does the initial cracking of a concrete pavement slab. The relative service behavior of the two types subsequent to cracking—the ability of a bituminous top to bridge cracks, maintain the alignment of fractured slabs, etc., are matters of interest which it is extremely difficult to evaluate from experimental data. It is still necessary unfortunately in this matter to fall back upon the results of practical experience.

Researches along the second line; that is, those concerned with the measurement of impact produced by actual motor trucks on pavements, have been in progress for several years. Since 1923 the work has been done in cooperation with the Society of Automotive Engineers and the Rubber Association of Amer-

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[1] Tests of Impact on Pavements, Pub. Rds., Vol. 4, Nos. 6 and 7.

[2] Impact Tests on Concrete Pavement Slabs, Pub. Rds., Vol. 5, No. 2.

[3] Motor Truck Impact Tests, Pub. Rds., Vol. 7, No. 4.

Figure 1
INFLUENCE OF TIRES ON VERTICAL IMPACT REACTIONS

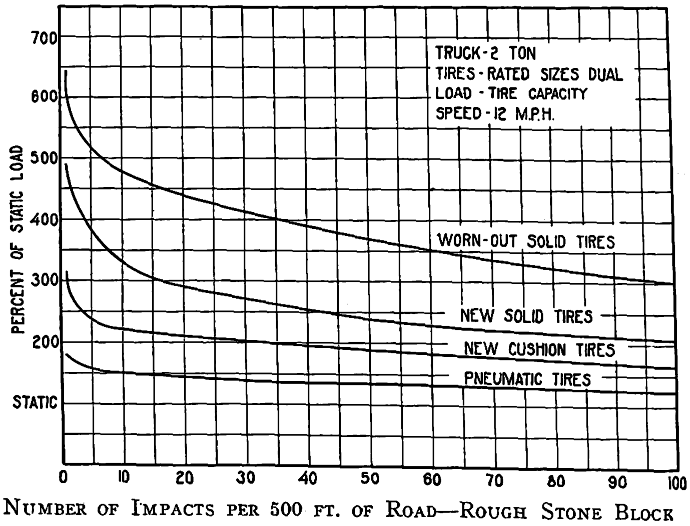
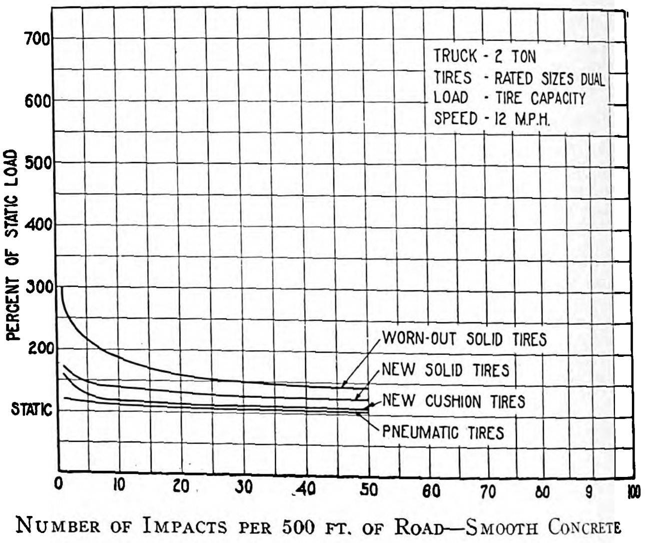


Figure 2
INFLUENCE OF TIRES ON VERTICAL IMPACT REACTIONS



ica. A progress report covering the work done up to 1926 has been published[3] and it will be necessary here to call attention to only a few of the outstanding conclusions which have been drawn.

The impact delivered by a moving truck when it strikes or drops from an obstruction was measured in these tests by means of an instrument known as an "accelerometer." The total impact force transmitted to the pavement is made up of two components; that due to the unsprung portion of the vehicle which is the part below, and not supported by the truck springs, and that portion supported by the truck springs, the major part of which is, of course, the body and its load. It is the function of the accelerometer to measure and record the acceleration or deceleration of the truck wheel upon striking a blow; that is, to measure the rate of change of velocity of the wheel from the moment it strikes until it is brought completely to rest. The force of the blow caused by the unsprung weight may then be obtained by the use of the fundamental equation $F = ma$, m being the mass of the unsprung portion of the truck. To obtain the total impact force, it is necessary to add to this quantity the spring pressure in pounds at the instant of impact. This latter value is obtained by determining the relative deflection of the truck spring at the instant of impact as compared to its deflection under static conditions. This value is also recorded autographically by the accelerometer. Detailed descriptions of this and other types of accelerometers have been published by the bureau.[4]

The four major factors which affect road impact reactions are (1) the type and condition of the tires, (2) the speed of the truck, (3) the wheel load and (4) the roughness of the road or pavement.

Numerous tests have been made in which each of these factors has been varied in turn and their relative importance under different conditions determined. The actual impact conditions have been produced (1) by driving the trucks over artificial obstructions of various heights placed upon a test pavement, and (2) by operating the trucks over actual pavements of different types and degrees of roughness.

One of the most interesting phases of this investigation has been the preliminary study of the effect of road roughness. Test trucks were operated on two pavements having a marked difference in surface roughness and the results show that poor tire equipment may be exceptionally severe even on a smooth road while good tire equipment considerably reduces the impact effect on a rough road. For instance, for a certain test condition in which 2-ton trucks loaded to rated tire capacity were operated at a speed of 12 miles per hour, the impact reaction which occurred on an average of once in every 10 feet of road length showed the following relationship: On the smooth road this reaction exceeded the static load by 5% for pneumatic tires and 45% for worn-out solid tires; on the rough road the excess over the static load was 40% for pneumatic tires and 270% for worn-out solid tires. (Figs. 1 and 2.) The advantage of smooth pavements, aside from considerations of riding qualities, is thus emphasized.

To provide data which may serve as a basis for design and for the intelligent drafting of motor vehicle regulations, this portion of the investigation has been extended to determine the impacts which variations in load, speed and tire equipment may be expected to produce on pavements of various types and degrees of roughness.

Another point which it may be of interest to note is that, while the impact force delivered by a truck increases with its static load, the ratio of impact to static load actually decreases. This may be attributed to the major effect of the unsprung weight and the fact that the ratio of unsprung to total weight decreases with increased gross loads.

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[3] Motor Truck Impact Tests, Pub. Rds., Vol. 7, No. 4.

[4] Accurate Accelerometer Developed by Bureau of Public Roads, Pub. Rds., Vol. 4, No. 10, Dec. 1924.

Increasing the thickness of tread rubber has also a marked effect in reducing impact. Conversely, variations in cross-sectional rubber or breaks in its continuity greatly increases impact, which leads to the recommendation that dual tires be mounted with the tread designs staggered.

Due to lack of time, it is of course impossible to go into a detailed description of our studies in any great detail. As has been noted, however, progress reports have appeared from time to time in PUBLIC ROADS and these are available to any one interested in going into the subject further.

Quality Control of Concrete for Pavements and Pavement Foundations

Before attempting a discussion of this subject it may be well to consider just what is involved in the expression "quality control." Broadly speaking, the term "quality control" should cover supervision over all of the materials and processes involved in the manufacture of the product which, in the case of concrete, would include

(1) the inspection and testing of all of the constituent materials,
(2) the determination of the relative proportion of each to insure concrete of the desired quality. (Design of the mix.)
(3) Field inspection of methods of
    (a) Proportioning
    (b) Mixing
    (c) Placing
    (d) Curing
(4) Inspection and testing of the product.

In other words, every step in the manufacturing process, from the initial tests of the cement and aggregates to the time when the structure is ready for use as designed.

Although the failure of a pavement or pavement foundation does not in general involve the hazard of human life, the great initial cost of such work, together with the severity of the destructive agencies to which it is subjected, makes it imperative that the greatest care be exercised to insure a satisfactory structure. This, in turn, presupposes an adequate, efficient and honest inspection organization in whose hands should be placed the responsibility for exercising quality control.

The following discussion will be concerned primarily with the second item enumerated above; that is, design of the mixture, because it is felt that in this one feature lies probably the greatest opportunity for improving the quality of the product—not that the other items are not important—far from it. They involve, however, the application of well and long established engineering principles. When it comes to the matter of proportioning, however, we must confess that practice lags far behind theory. Nor is it necessary that we all agree on any one of the many suggested methods for designing concrete mixtures. Almost any of them are better than the present practice of arbitrarily setting a given proportion of cement, sand and coarse aggregate and expecting concrete of uniform quality and definite strength.

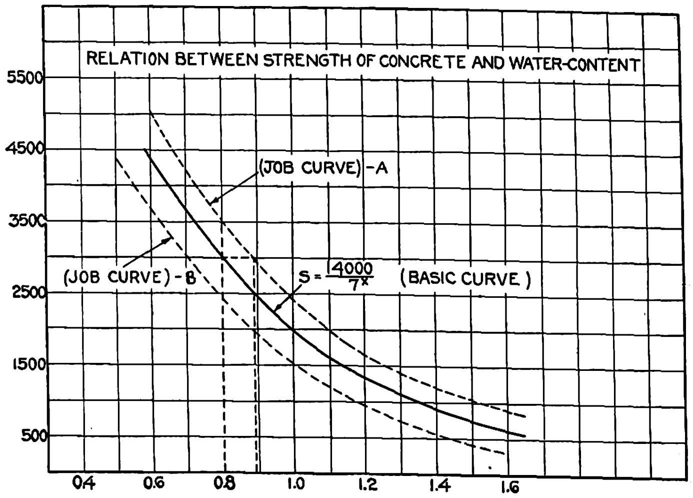
It is my purpose here to discuss a suggested application of the water-cement ratio theory of proportioning concrete, because I believe that basically the water-cement ratio theory is sound and that if intelligently used and properly safeguarded, it will produce more uniform concrete closer to the desired strength than it is possible to obtain by the present method of arbitrary proportioning.

The water-cement ratio theory in general teaches us that so long as the aggregates are clean and structurally sound, and the concrete is workable, its strength will be a function of the ratio of water to cement in the mix. Furthermore, that there is a mathematical relation between strength and water-cement ratio which may be expressed by the equation $S = \frac{14000}{7x}$ in which S is the unit strength and x an exponent, the water-cement ratio. Numerous tests have shown that, on the basis of average materials and conditions, this equation holds true. It can not be considered, however, to necessarily apply directly to *any* particular condition or combination of materials, without modification—the modification consisting in substituting another constant or the value 7 in the equation which is the constant representing average conditions. The value of this constant for a particular condition would depend upon the materials to be used on the job. Any change in the constant will of course not change the form of the fundamental curve at all but simply its position on the chart, curves obtained from smaller values lying above the basic curve and those obtained from larger values lying below the basic curve. The practical necessity of limiting the water-cement ratio theory as originally published has been recognized repeatedly by engineers and contractors who have attempted to put it into practice. Variation in other or both aggregates or in the cement will cause variation in strength with the *same* water-cement ratio. For a given set of materials, however, a given water-cement ratio will produce concrete of a certain strength irrespective of the proportions or gradation of the aggregates just so long as the concrete is workable.

This, of course, does not mean that either the proportion or the gradation can be varied at will without affecting the strength. The element of workability, or it might be called "placeability," enters. Any variation in either the proportions or gradation will always result in a change in workability with a constant water-cement ratio.

The factors of water-cement ratio, workability and gradation form a three-way interrelation which is very interesting. You can not change one without changing at least one of the others. From the standpoint of efficient operation, it is always necessary to maintain as nearly constant workability as possible. It is also necessary to maintain a constant water-cement ratio. It follows, therefore, that on any work in which the concrete is designed by this theory, arrangements must be made for securing aggregates which will have the same gradation throughout the progress of the work. Of course, the same thing is necessary (though seldom required) under the method of proportioning by arbitrary mixes. The difference is that by using the water-cement theory, it is possible to design the mix so as to make the best use of the aggregates which are available, whereas by the arbitrary method, either a definite mix is specified with relatively wide limitations as to grading of the aggregates, resulting in possibly wide variations in uniformity, or the aggregate gradings are so restricted as to eliminate possibly more available materials which would have proved just as satisfactory if the proper mix had been used.

Figure 3



WATER CEMENT RATIO
FIGURES AT LEFT OF DIAGRAM SHOW CRUSHING STRENGTH—POUNDS PER SQUARE INCH—28 DAYS

The application of the water-cement theory of design can probably be best illustrated by means of an example. In Fig. 3, the basic water-cement strength curve is plotted as a solid line. Its equation is $S = \frac{14000}{7x}$. This, as has been pointed out, may be considered an average curve covering a wide range of materials. It can not, however, be considered to apply directly to any particular combination of materials, but may be used in deriving a curve which does apply. Let us assume, for instance, that it is desired to construct a concrete pavement and that certain typical combinations of cement and aggregates are available. For purposes of illustration, we will take two combinations in which the *sand* only varies, the cement and coarse aggregate remaining the same. It is first necessary to determine the proper ratio of fine to coarse aggregate to use, and this ratio will vary with the size and gradation of each aggregate. The determination may be made by trial or the fineness modulus method may be used. By this method, which I believe has possibilities in so far at least as this feature of the design is concerned, the correct percentage of sand may be calculated from the known fineness modulii of each aggregate and an assumed fineness modulus for the combination, based on the maximum size of the coarse aggregate.

Having determined the proper ratio of fine to coarse aggregate for each sand, we shall further assume that we desire to obtain concrete which will give a crushing strength of 3,000 lb. per sq. in. at 28 days. Reference to the basic curve shows that to obtain this strength under average conditions, a water-cement ratio of 0.8 must be used. We shall now proceed to make concrete specimens of each of our combinations, using just sufficient cement and water in the ratio of 0.8 to give us the workability desired. In order to compare the economic advantages of the two sands in question, accurate determination of yield of concrete should also be made.

The next step in the design must await the results of the strength tests. Let us suppose that in the case of sand *A*, we obtain a crushing strength averaging 3,500 lbs. per sq. in., and in the case of sand *B*, 2,500 lbs. per sq. in. instead of 3,000 lbs. as called for on the chart. By plotting these points on the chart and drawing through each of them a curve *parallel* to the basic curve, we obtain two job curves. Job curve *A* expresses the water-cement strength relation for the combination, using sand *A*, and job curve *B* a similar relation for the combination using sand *B*. Similar analyses may be readily made, varying either the cement or the coarse aggregate.

For the particular work in hand, however, we specify 3,000 lbs. per square inch, no more and no less. If we wish to use sand *A*, therefore, we follow *down* job curve *A* until it intersects the 3,000 lb. line and read on the scale below the corresponding water-cement ratio which in this case is 0.9. If we wish to use sand *B*, we follow *up* job curve *B* until it intersects the 3,000 lb. line and read the corresponding water-cement ratio which is 0.7. It will be seen therefore that if we elect to use sand *A* rather than sand *B*, it will be possible to use a considerably higher W/C which for a constant consistency means a considerably leaner mix, measured in terms of cement to total aggregate. Whether it would be economical to use sand *A* under those circumstances would depend entirely on the relative cost of the two sands delivered on the job. It is conceivable that sand *B* might be sufficiently cheaper to warrant the use of the additional cement.

I do not wish to be understood as believing that the entire problem of concrete design has been solved by the application of the water-cement ratio theory. I do believe, however, that having once recognized its limitations and if used subject to these limitations, it furnishes the most practical method yet devised for arriving at a rational solution of a problem to which rule of thumb methods have so far been applied. I realize, too, the practical difficulties in the way, not the least of which is the absolute necessity of educating the material dealer to the realization that having once contracted to supply an aggregate of specified characteristic, including grading, he is found to continue supplying the same material until he has fulfilled his contract. Some of you from your past experiences may be inclined to doubt whether such a thing is possible. For my part, I believe that there is a growing realization among the more reputable dealers that a quality product pays in the long run and that rational methods of design having been established, we would not long have trouble from this source.

There is one additional point relative to the application of the water-cement theory which is of interest in connection with concrete paving work. There is a well-defined feeling that flexural strength rather than crushing strength is the most essential characteristic of paving concrete—furthermore, that the same ratio of flexure to compression does not apply in all cases. I do not see why this fact should interfere with the logical application of the theory that, for a given job combination of materials, strength (flexural as well as crushing) is proportional to water ratio. The same procedure exactly is required in the analyzing of the strength and yield characteristic of the materials except that flexural tests are made instead of crushing tests.

While on the subject of flexure, it may be interesting to note the increasing use of this test as a measure of the necessary curing period for concrete pavements. It is well known that the rate at which concrete hardens varies with the character of the cement, the weather conditions, etc., and that frequently a fortunate combination of these factors will produce concrete of satisfactory strength in much less than the conventional curing period. Flexure tests made periodically on all jobs during the curing period furnish a very satisfactory method of accurately determining how long traffic must be kept off the road and when it may be opened to restricted traffic, such as touring cars, etc. It has been used with marked success by the Pennsylvania Highway Department.

I can not pass over the subject of quality control of concrete without touching upon a related phase of the same problem which is only beginning to receive adequate consideration. I refer to the economic consideration involved. In estimating for highway work, it has been the universal practice in the past to assume that a given arbitrary mix will require a definite amount of cement per cubic yard. We all know that there are many factors other than proportions which affect yield and it can safely be said that on the average job an intelligent study of the relative importance of these factors in influencing the yield of the concrete will be amply repaid, not only in actual savings in materials but also in indirect savings effected through ease in handling and finishing the concrete as well as the general increased efficiency of the force which results from the handling of a *uniform* product.

With regard to the possibilities of quality control of concrete produced under existing specifications, I believe that, in the past, lax construction methods have accounted for the most of the poor concrete which we see today. At the beginning of this discussion, I stated that I did not intend to dwell upon those details of the manufacturing process which involved well and long established engineering principles. I refer of course to the necessity of having materials of satisfactory quality, accurate methods of measurement, adequate mixers and complete curing. It must be confessed, however, that it is through the disregard of such fundamental principles that many structures fail to give the service for which they were designed. Dirty materials, inaccurate measurement, under-mixing, too much water, poor finishing, inadequate curing, as well as a long trail of minor ills, all contribute to defective concrete and in almost all cases are due to either inefficient or dishonest inspection.

Nor do I discount the disastrous effect of political interference, which if allowed to enter will of course destroy in no time the value of the most efficient inspection organization ever assembled. We need, however, to educate the Engineer, the Contractor and the Material man that quality control pays—pays not only increased service rendered by the product but in dollars and cents as well, through a more intelligent method of selecting and combining the available materials, resulting in a cheaper as well as as a better product.

Does inspection pay? Travel over some of the modern highways constructed in a State where rigid control of all materials and construction processes prevails. Then ride over some of the roads built in another jurisdiction where no control or just nominal control exists and read the answer.

DISCUSSION

MR. ROSENGARTEN: I would ask in regard to the impact tests referred to at the beginning, is there not a difference in the character of impact that is delivered, for instance by the pneumatic tire, by the new solid tire, and going still further, by the worn solid tire? And is there not more of a transfer from what we might call a suddenly applied load to one of actual impact, and if so, were there any tests tried out at Arlington on those slabs with worn tires, worn solid tires, because, as I would see it, those are the tires that would cause failure in the bases under the pavements?

MR. JACKSON: In the first series of impact tests on slabs, we used only solid tires in good condition. It was only in the subsequent tests in which we used trucks with various types of tires, that is, pneumatics versus solids, and worn out solid tires versus good solids. It was undoubtedly true, as you saw from the chart, the worn out solid exerts much severer impact on the pavement than a good solid tire. It is simply a question, as I see it, and as we have interpreted it at Washington, of the length of time it takes for that tire to come to rest after it strikes the pavement. The quicker it is brought to rest the higher will be the impact force; the slower it comes to rest, the lower will be the impact force. It is perfectly easy to see that with the pneumatic tire the whole vehicle is brought to rest much slower, through the cushioning properties of the air, than would be the case with the solid tire.

MR. ROSENGARTEN: In that connection, the Asphalt Association made some tests about seven years ago on impacts on slabs, and those tests, as reported in some of their publications, show that the cushioning effect of the asphalt surface was quite marked, and especially is that the case with the thicker asphalt surfaces, for instance, 3"—and some of the tests were run with 4" asphalt tops. Those tests were conducted with a steel ball, which naturally applied a suddenly applied load, a real impact, rather than a load that increases from zero up to a maximum impact. Therefore, if the tests of the Bureau of Public Roads were run with a worn tire, it would seem to me that possibly there might have been a little more of the cushioning effect of an asphaltic surface indicated.

MR. JACKSON: I think, Mr. Chairman, it is quite possible there would have been.

"Studies of the Pennsylvania Department of Highways on Pavement Slabs and Strengthening Foundations"

By P. M. TEBBS

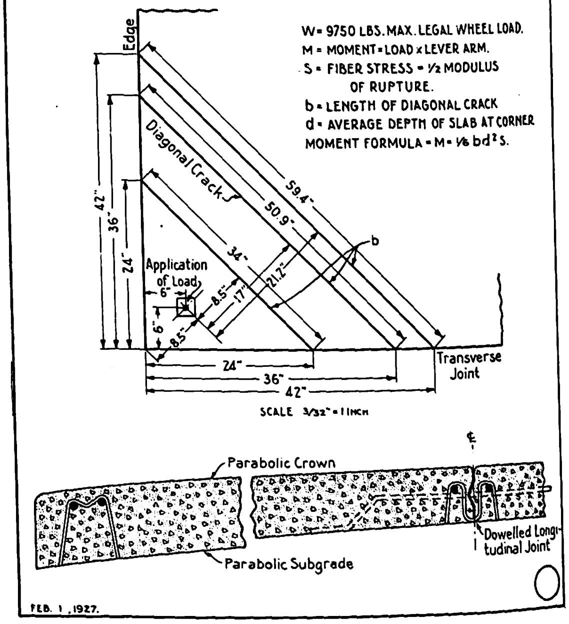
Headquarters Field Engineer of the Department of Highways, Pennsylvania

Standard Rural Highway Foundation Design

IN designing concrete foundations, the Pennsylvania Department of Highways works upon the basis that the edges must be thickened for additional strength on all rural highways with subgrade and shoulders of natural materials. The strength of pavement required is determined for the maximum legal wheel load of 9,750 pounds, assumed as being placed six inches (6") in from the outer edge of the end of a slab and the stress is computed for the corner acting as a cantilever supported along a line two feet (2') in from the corner, along the straight sides of the corner. The concrete mixture used in the foundation is 1-2½-5. No reinforcing is used in the foundation. A modulus of rupture of 540 pounds per square inch is used for this concrete and the fiber stress (S) used in the design formula is one-half of the modulus of rupture or 270 pounds per square inch. The modulus of rupture and fiber stress being nearly the same for this material, this is equivalent to introducing a factor of safety of 2 and is based upon the determinations in the Bates road test. These conditions are shown in Figure 1.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HIGHWAYS
MAXIMUM LOAD AT CORNER AND SOLUTION OF STRESSES FOR STATIC LOAD.

FIG. 1.


Edge
W = 9750 LBS. MAX. LEGAL WHEEL LOAD.
M = MOMENT = LOAD × LEVER ARM.
S = FIBER STRESS = ½ MODULUS OF RUPTURE.
b = LENGTH OF DIAGONAL CRACK
d = AVERAGE DEPTH OF SLAB AT CORNER
MOMENT FORMULA = M = 1/6 bd² S.
Diagonal Crack
59.4"
50.9"
34"
21.2"
17"
8.5"
8.5"
b
42"
36"
24"
Application of Load
6"
6"
24"
36"
42"
Transverse Joint
SCALE 3/32" = 1 INCH
Parabolic Crown
Parabolic Subgrade
Dowelled Longitudinal Joint
FEB. 1, 1927.

No value for slab strength of the wearing surface is used, but the wearing surface is considered to act as a protection to the foundation, reducing the amount of impact transmitted to the foundation and also protecting the foundation against quick temperature and moisture changes, thereby reducing edge curling. The thickness of the edge determined by the formula under the above conditions is 7.4 inches. Since a monolithic flush header curb is constructed along the foundation and has some value in strengthening the edge, we would consider a seven-inch (7") thickness at the edge to be adequate, under ordinary rural traffic conditions. The minimum thickness at the center used is seven-tenths (.7) of the computed edge thickness or five inches (5"). The subgrade under the center of the pavement is generally more stable, being better protected against moisture changes than the edges with earth shoulders. This method of determining center thickness is in accordance with the results of the Bates road test.

The thickness of the foundation determined above would not be used for heavy traffic. In cases where heavy rural traffic is anticipated, a foundation with an edge thickness of eight inches (8″) and a center thickness of six inches (6″) would be used.

No longitudinal joints to divide concrete foundations into separate longitudinal lanes have been used excepting where extra width over the standard two lane pavement is to be constructed. For pavements of extra width with high curb, the depth of foundation is made uniform and one-half inch (½″) greater in depth than the computed center depth of the standard two lane road. The addition of the half-inch in depth for uniform depth foundation and pavements over the computed center thickness is an arbitrary allowance on the side of safety and amounts to a reduction of some twenty percent in the modulus of rupture. This design is justified by the fact that the subgrade will be much more uniform under a full width pavement between curbs and the edges adjacent to the curbs do not ordinarily require additional thickness, since there is not a considerable amount of moving traffic close to the curb.

The foundation of uniform depth as above determined is used only where there is a doweling or a keying of the slab on one side of a joint or crack to the other side, whereby a portion of the load imposed on one side of the joint or crack is transmitted across the crack or joint. Otherwise, the foundation should be of greater depth.

Concrete Pavement Design.

The design of a plain concrete pavement is based upon the same theory as previously described for foundations, excepting that it is designed for a corner acting as a cantilever with the support three feet from the corner, which results in a lever arm of seventeen inches (17″), as shown in Figure 1. The standard concrete mixture used is 1-2-3. A modulus of rupture of 600 pounds per square inch is used for this concrete or a fiber stress (S) of 300 pounds per square inch. Based on these factors of design, the terminal traffic section which has an edge thickness of nine inches (9″) and a center thickness of six and one-half inches (6½″) would have a maximum fiber stress of 283 pounds per square inch, which is therefore well within the limit set. The eight and one-half by six inch pavement for moderately heavy traffic would have a stress of 321 pounds per square inch, and the eight by six inch pavement for average traffic would have a stress of 352 pounds.

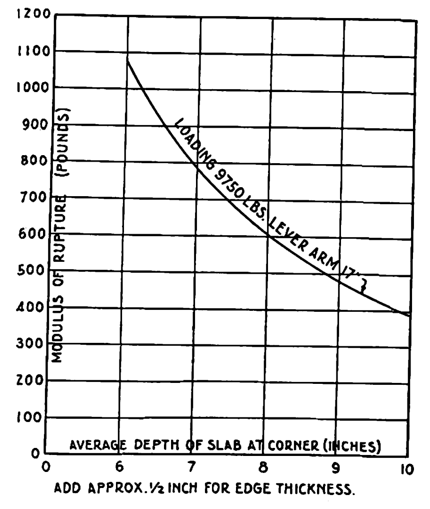
Reinforced Concrete Pavements.

Concrete pavements are reinforced by placing two ⅝-inch bars at distances of four and eight inches from the outer edge of the pavement and two inches below the surface, with stirrups. The cross section is shown in Figure 1. At transverse expansion joints one bar is placed four inches from the joint and likewise one ⅝-inch bar is placed on either side of the center joint and four inches from it. Although these reinforcing bars do not entirely prevent cracks occurring in the pavement, they do assist in reducing contraction cracks and in holding the parts close together and prevent progressive disintegration of the pavement slab which might otherwise begin at the cracks or joints. The stirrups on the reinforcing bars act to prevent buckling of the bars while the concrete is hardening and contracting. We assume the value of the reinforcement to be 15 per cent, in resisting moment, which is conservative. Therefore, on this basis the fiber stress in the nine by six and one-half inch pavement would be 244 pounds per square inch; in the eight and one-half by six inch pavement would be 280 pounds; and in the eight by six inch pavement would be 306 pounds. These compare favorably to the 300 pounds safe fiber stress generally used.

The doweled longitudinal joint shown in Figure 1 is used in concrete pavements and avoids longitudinal cracks, serves to drive the pavement into traffic lanes and acting as a hinge allows the slabs better contact with the subgrade by reducing the lifting of the edges by curling. It is formed by a deformed metal sheet of 14 gauge U. S. standard, and the slabs are held together at the center joint by one-half inch dowel bars four feet in length, placed five feet on centers. This doweled joint including metal plate costs about $0.15 per linear foot.

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HIGHWAYS
MODULUS OF RUPTURE -
DEPTH OF CORNER CURVE.

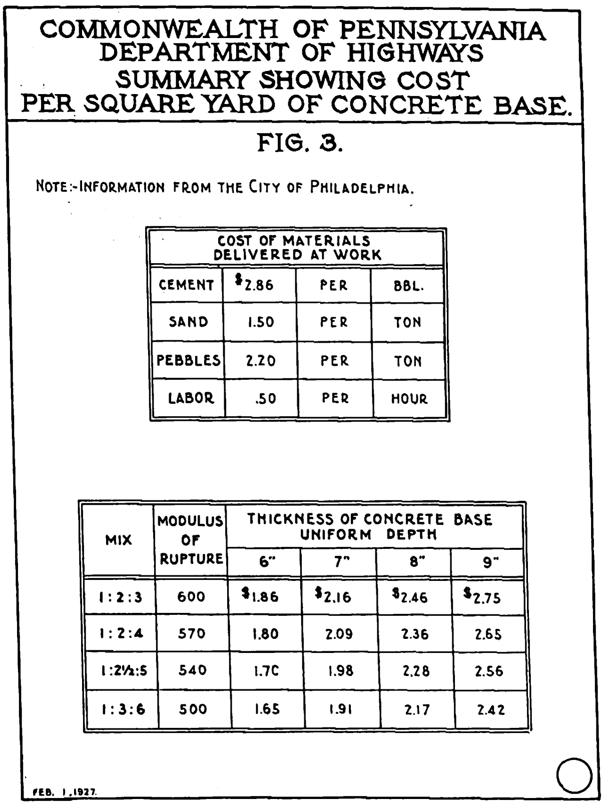
FIG. 2.



FEB. 1, 1927.

In the case of terminal highways or city pavements subject to heavy loads, the foundation should be designed on the conservative basis described for concrete pavements. The required thickness for any given modulus can readily be secured from Figure 2, or the heaviest depth of foundation, using 1-2½-5 concrete, based upon a conservative modulus of rupture of 500 pounds, would be 9 inches in average corner depth or 9½ inches in depth at the edge and 7 inches in depth at any doweled interior joint, according to Pennsylvania's practice, therefore the uniform depth of foundation in this case would be 7½ inches. There is a suggested loading of 12,800 pounds on one wheel for terminal area design under consideration by a committee of a national organization at this time, which, if adopted, will allow for various factors including overloading. This would result in a depth of foundation for a conservative modulus of rupture (500 pounds) for 1-2½-5 concrete of 10 inches for an average corner depth, 10½ inches for a thickened edge depth and 7½ inches for the depth of slab at a doweled interior joint. The uniform depth of foundation equivalent to this foundation would be 8 inches.

Figure 3 gives estimated costs of various depths of plain concrete formation of various mixtures with safe moduli of rupture from which, with the use of Figure 2, the most economic depth and mixture of concrete can be determined.



COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF HIGHWAYS
SUMMARY SHOWING COST
PER SQUARE YARD OF CONCRETE BASE.

FIG. 3.

NOTE:-INFORMATION FROM THE CITY OF PHILADELPHIA.

COST OF MATERIALS DELIVERED AT WORK			
CEMENT	$2.86	PER	BBL.
SAND	1.50	PER	TON
PEBBLES	2.20	PER	TON
LABOR	.50	PER	HOUR

MIX	MODULUS OF RUPTURE	THICKNESS OF CONCRETE BASE UNIFORM DEPTH			
		6"	7"	8"	9"
1:2:3	600	$1.86	$2.16	$2.46	$2.75
1:2:4	570	1.80	2.09	2.36	2.65
1:2½:5	540	1.70	1.98	2.28	2.56
1:3:6	500	1.65	1.91	2.17	2.42

FEB. 1, 1927.

A report of the National Research Council indicates that a metal fabric of from forty to sixty pounds weight per one hundred square feet placed in the concrete has resulted in less cracks than have resulted from an extra inch of depth of concrete. A fabric weighing about forty-five pounds is placed for about twenty cents (.20) per square yard, and an inch depth of 1-2½-5 concrete costs about $0.30 per square yard, indicating economy in the use of metal fabric. The fabric acts to dowel the pieces together, when cracks do occur.

The bearing power of the subgrade is an important factor and a depth of foundation should be used which will transmit the load to the subgrade over an area where the subgrade at the time of its least resistance will bear the load safely. Pennsylvania's pavement and foundation designs anticipate proper subgrade preparation, but the value of any subgrade varies with the character of the material and the amount of moisture present. Sandy or gravelly soils with a low moisture content will bear safely much heavier loads than is the case where the subgrade may consist of clay or similar material with a high water content. It will, therefore, be necessary to use a heavier pavement slab or foundation course in the case of less stable soil conditions. This emphasizes the necessity of drainage in order to increase its bearing power. Dr. Westergaard's investigations including allowance for varying subgrade bearing values indicate that the depth of foundation should be varied with the stability of the subgrade. (See National Research Council reports.)

Tests of concrete indicate great variations in the strength of concrete due to inaccurate proportioning, mixing, control of consistency and segregation by handling. It is, therefore, essential that every possible method or device should be used during construction in order to eliminate these variations.

There has been found to be a variation in strength of 25 per cent, between properly and improperly cured concrete, and curing is therefore an important factor in the strength of the concrete.

There is little use of designing the foundation for any strength of concrete unless it is protected against damage by traffic until it has attained the required strength and it is, therefore, essential that the foundation be kept free from traffic until it has attained the strength required or where it is uneconomical to keep a pavement closed for an extended period, some proven quick hardening concrete should be used and allowed to attain the required strength before traffic is permitted to pass over it.

The smoothness of the surface is an important factor since the loads on the pavement are greatly increased by impact due to surface roughness. By reference to Public Roads of June, 1926, you will find the results of tests which emphasize the great increase in stress occasioned by impact due to surface irregularities with tires of varying resilience.

Where pavements must be laid to manholes and similar structures in the surface, it is impracticable to construct and maintain a smooth surface. Due to the various influences, impact will result and it is therefore recommended that the depth of the foundation be increased to the computed edge thickness adjacent to all such structures.

(Record of Conference will be continued in June issue)

The Business Situation

The monthly Bulletin for May issued by the Cleveland Trust Company and so ably edited by Colonel Leonard P. Ayers, covers the present Business Situation in such a thoroughly reasonable manner that we are quoting very fully as follows:

PROSPERITY, like prohibition, is proving to be very different from what we expected it to be. It is becoming apparent that protracted prosperity during a period of declining commodity prices produces the keenest kind of business competition. This is an unexpected development, for we have never previously experienced a long period of prosperity during which the general level of commodity prices persisted in declining.

"The fact that prices keep on slowly going down means that the supplies of goods tend to be a little greater than the active demand for them, so that sellers are finding themselves constantly compelled to make price concessions, and buyers are continually demanding better terms. The result in many lines is that the only producers who can operate at a profit are those who can so increase the efficiency of their manufacturing processes as to reduce their operating costs about as rapidly as the price levels of their commodities decline. Those who cannot do so are encountering serious difficulties.

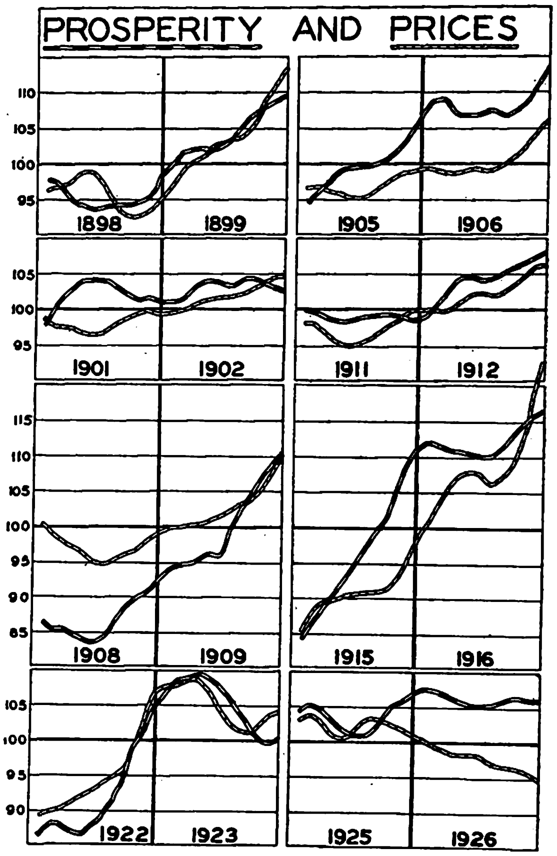
"There is no doubt that the country as a whole is enjoying an era of exceptional prosperity which has lasted with only brief interruptions since the latter part of 1922. Our national income is nearly three times as great as it was just before the war. Employment is general and the purchasing power of the industrial worker's wages is greater than it has ever been before either in this country or in any other. The volumes of industrial profits are greater than at any previous time.

"It is probable that national prosperity will remain at a high level during the remaining months of 1927, and that business competition will continue to be so keen that many businessmen engaged in trade and industry and agriculture will find it difficult to believe that the prevailing prosperity they read about actually exists. Business profits will probably be large in the aggregate, and they will tend to go mainly to the firms that operate so efficiently that they can undersell their competitors, or that produce goods which are distinctively more attractive than the average, or that have arranged by mergers or agreements to avoid the extremes of competition.

Prosperity and Prices

"The outstanding difference between this prosperity and previous periods of good business is that in former years almost all business firms made good profits when production volumes were large and employment was general, while now increasing numbers of them are hard put to it to make any profits at all. The present trouble is not with the aggregate volume of profits being made, but rather with their distribution.

The cause of the most serious difficulties that many businesses are encountering is to be found in the steadily declining levels of wholesale commodity prices. In the diagram there are eight pairs of lines representing the movements of general business and of wholesale prices in eight two-year periods of business recovery and prosperity. The solid lines represent the movements of general business below or above the normal level which is represented by 100. The dotted lines show the course of wholesale commodity prices if the average for each two years is taken as 100. In each period except the present one rising prices have accompanied advancing business. This time business stays well above normal while the price level persistently sags downward.



"Meanwhile employment conditions have been good and industrial wages have remained high, with the result that the American people have had in the aggregate an enormous purchasing power. But because commodity prices have been declining there has been little commodity speculation either in the open markets or in the form of the building up of inventories. No one has wanted to accumulate any more stocks of goods than necessary because it was probable that if they were held long they would decline in value. This has produced hand-to-mouth buying. It has brought about a close and responsive relationship between demand and supply.

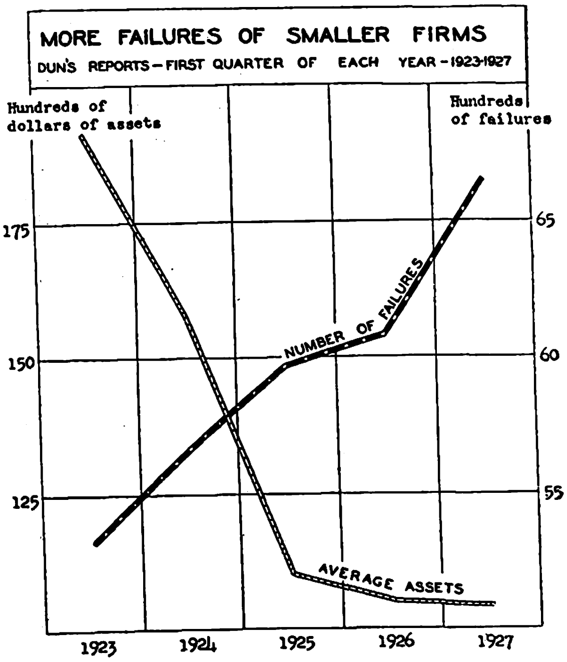
"In the previous periods of prosperity when prices have risen merchants and jobbers have ordered ahead of their needs because they have realized that prices would be higher later on. Manufacturers speeded up production and increased their inventories for the same reasons. This resulted in advancing wages and competition for labor. For a year or so under such conditions almost everybody would make money, the inefficient producers and merchants along with the efficient ones. After a time the upward surge of industrial output would bring about freight car shortages on the railroads, and the increases in industrial payrolls, along with speculation and advancing prices, would call for so much currency as to result in credit stringencies. Then that period of prosperity would be at an end.

"Under present conditions with declining prices these self generated destructive results of prosperity have not appeared. National income has been high, and national savings large, with the result that interest rates have remained low. Production has become progressively more efficient, and those manufacturers who have been most successful in reducing their costs of operation have made large profits. But now it is beginning to be apparent that many manufacturers have reached, or are reaching, the limits of their ability to reduce their costs of production.

Smaller Firms Failing

"The competition that has come with this period of protracted prosperity and declining prices is a long-distance race in which the short-winded participants are being left behind. The evidence of this is to be found in the records of commercial insolvencies. Failures are increasing in number. There were more of them in the first quarter of 1927 than in the first quarter of any previous year expect 1922 and 1915 which were both periods of serious business depression.

"These failures, which are rapidly increasing in number, are largely suspensions of smaller firms. In the diagram the heavy rising line represents the increasing numbers of commercial insolvencies during the first quarters of each of the past five years. The lighter declining line represents the average assets of the firms, and indicates that it is in the main the smaller companies that are being forced to suspend. A line representing the average liabilities would show the same tendency, although it would be more irregular, and would have an advance in this past quarter owing to the inclusion in 1927 of several large failures.



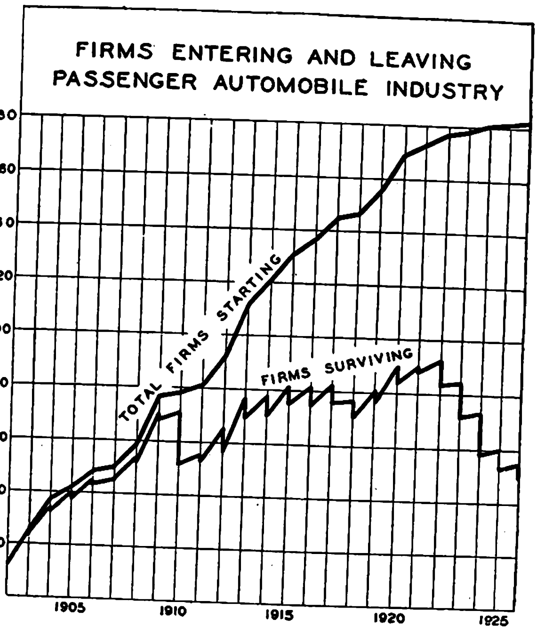
"The figures confirm the observations that one may readily derive from reading the financial pages of the newspapers. Last year the General Motors Corporation made the largest profits in its history, but most of the smaller automobile companies report earnings that were sharply reduced below those of 1925. The current profits of the leading steel producer are very great, but most of the smaller companies are reporting large volumes of output and shrinking margins of earnings. In the security markets the shares of the leading corporations in many if not most important branches of business have made notable price advances during the past year, but the quotations for the shares of some hundreds of smaller companies are lower than they were at the beginning of 1926. This is a time of prosperity for the efficient and strong, and one of increasing difficulties for those that are less successful in reducing their costs of production, or that are handicapped by inadequacy of capital.

"The same economic conditions that are creating difficulties for large numbers of manufacturing and mercantile firms are greatly benefiting the railroads and the utilities. These companies sell services instead of goods. The activity of general business brings traffic to the railroads in great volume, and increases the demands for power from the electric companies. In the case of the railroads and of most utilities these exceptional demands do not result in bringing new competitors into the field. The declining commodity prices tend to reduce the costs of coal and equipment, but the rates that the companies charge for their services remain at the relatively high levels at which they were fixed by the commerce and public service commissions when costs were higher. The influences of the prevailing fundamental economic conditions greatly favor the railroads and the utilities, and this is reflected in the buoyant action of their securities on the stock exchanges.

Competition of Motor Firms

"During the 25 years since 1902 some 182 firms have engaged in the manufacture of passenger automobiles on a commercial scale. At the beginning of this year only 50 of them remained in business. These figures are taken from two excellent articles recently published in the Harvard Business Review by Mr. Ralph C. Epstein of the University of Buffalo, and from additional data furnished by him. In arriving at these figures only firms that actually conducted manufacturing on a considerable scale are taken into account. Separate companies operated by a single corporation, as in the case of General Motors, are counted as individual units while companies that changed names and management but did not go out of business are considered as being continuing concerns.

"This brief but eventful history of the rise and fall of firms entering and leaving the industry is illustrated in the diagram. The upper, continuous line shows the total number of firms that entered the business from 1902 through 1926. Starting with only 12 companies the line continues on an irregular upward course until it reaches 182 at the end of 1926. The additions in the earlier years came rapidly, but in



the past seven there have been only a few of them. The lower, irregular line shows the number of firms surviving each year. It has been falling rapidly since 1922.

"The keen competition that prevails in manufacturing industry in general is present in exceptional degree among the manufacturers of automobiles. When the records are brought up to date a few years hence they will probably show that still more firms have dropped out, that others have survived by entering mergers, and that very few new firms have come into the field. No doubt some relatively small companies will continue to succeed by skilled management and by successfully meeting special demands, but the major part of the great profits of the industry are being earned by a few very large companies."

THE NATIONAL CITY BANK OF NEW YORK, in its May letter, writes:

The Trend of Corporation Earnings

"Business earnings statements now coming out for the first quarter make a mixed showing, with slightly over half of the companies reporting gains as compared with a year ago. Of the steel companies, United States Steel gained slightly, but earnings of most other companies were less satisfactory, due to the somewhat slow start of the industry on the new year and the lower prices quoted for steel products. Returns from the automobile industry were varied. While some of the oil companies did fairly well during the first quarter, the effect on others of over-production and price cutting was marked.

"Narrower margins of profit, coupled with the increase of business failures shown during recent months are indications of tendencies at work in business of which account must be taken. According to recent Government tables, prices of industrial materials as results of recent declines, are now at lowest levels since the war. Capacity in many lines to produce in excess of market requirements is resulting in a growing intensity of competition which is placing increasing pressure on the weaker and less efficient units of industry. It is manifesting itself not only in the smaller profits in some lines and a higher failure record, but also in more frequent mergers and the increased tendency for industries to seek a solution of their common problems through some form of co-operative action such as is exemplified by the recently formed Cotton Textile Institute. In the absence of any seriously disturbing symptoms in the business outlook, however, and with credit supplies continuing ample, we do not see any reason why needed adjustments should not go forward in a normal manner, at the same time affording ample opportunity to up-to-date well managed concerns for continued good business.

Money and Banking

"The money market moved along on an even keel during April, continuing the unusual stability displayed since the first of the year. Following the seasonal easing in January, call loan rates have held almost steadily at 4 per cent, showing neither the customary advance in February and March nor the usual decline in April. Bill rates have been almost unvarying 4¾-4⅝ per cent for 90-day acceptances, and time money and commercial paper rates have likewise been little changed. The latter eased slightly in February, recovering in March to present levels of 4 to 4¼ per cent for prime names."

The Magazine of Wall Street sums up the situation as follows:

"Some let-down in manufacturing activities and in distribution at wholesale and retail has lately come into evidence. This slackening appears to originate largely in seasonal influences. At the same time, since buying remains persistently of hand to mouth character and sellers are thus without a substantial back log of unfilled orders, they show some disposition to force business at the expense of prices. In other words, concessions are being granted in sundry directions. An exception is noted in the steel industry in the case sheets. Here producers have advanced quotations even though demand from the automobile industry has been tapering off. In general, the commodity price level has again shown a tendency to slip downward slightly.

"This lack of real or sustained resistance to decline on the part of prices reflects a condition of unstable equilibrium between current consumption and production. That is to say, producers, faced with high wages and operating costs generally, are inclined to hold production schedules to the highest possible point. Though public purchasing power is likewise high, the demand for goods is not quite up to the level of producing capacity so that a condition of increasing competition is the inevitable result. Since there has lately been a little less employment and since flood and weather conditions, along with the seasonal slackening of trade, have tended to further aggravate this lack of balance, it is probable that further irregularitiees will be shown in corporation earnings.

"The exceptionally strong credit situation, fortunately, alleviates much of the distress which might otherwise be caused smaller manufacturers and distributers under these conditions.

"Meanwhile, the lion's share of profits will doubtless continue to accrue to the larger companies and those endowed with shrewdest management."

Items of Interest

The Mississippi Flood Greatest in History

This has been a year of abnormal rains, and we are having not only the unprecedented floods of the lower Mississippi—the greatest flood in its entire history—but scores of lesser floods in the large tributary streams that feed into the Mississippi, and in other large river systems in the central part of the United States. Meteorologists can predict rains only a few days in advance; they can often predict floods due to incessant rains many days in advance. They can not say why we have the rains.

The floods began as far back as last October, due to heavy rains in August and September. They have gone on all winter in one region or another, augmented by rain, and more rain, swelling the smaller waterways, which in turn swelled the greater until we have now the terrible devastation that is being produced by the Mississippi. The Weather Bureau of the United States Department of Agriculture issued flood warnings constantly from October on through the winter in various localities, based on observations of rainfall and river stages, as one river system after another became affected by the long continued rains. The great Mississippi flood was not unheralded. Many thousands of people, taking advantage of advance warnings, moved their families and possessions beyond danger of overflowed waters. Others, unable to leave their homes or business properties, made what preparations they could to endure the period of flood hazards and anxiety. Unfortunately thousands of others have been unable to leave the threatened districts and are now suffering great hardships in spite of all efforts to warn and aid them.

The first flood of importance was that of the Neosho River in Kansas and Oklahoma in October. This was the greatest flood on record for that region. Then came more rains, extending over Ohio and the upper Mississippi Valley. These rains caused floods in all streams tributary to the Ohio. Normally October and November are the season of lowest water in rivers, yet in 1926 we came into early winter with nearly all the rivers in the Mississippi system, if not at "bankful" stage, at least at a stage much above normal. It was apparent to trained observers that with winter and early spring rainfall above normal any considerable increase must make big floods in the spring.

The rains came. The first great floods were in the southern tributaries of the Ohio, especially the Cumberland and Tennessee Rivers. Both went into "great flood" during the last days of 1926, so much so that the flood in the Cumberland was the greatest ever known in that river. These floods immediately filled all the lower Ohio above the flood stage. Later in January there was a big flood in the upper Ohio, which rose to nearly 30 feet at Pittsburgh and above 59 feet at Cincinnati. Then it began to rain more generally. Kansas and Oklahoma, Mississippi, Arkansas, Missouri, Illinois, southern Iowa, western Kentucky, western Tennessee, and later, Louisiana, all had heavy rains. The rains occurred at intervals not more than two or three days apart, and occasionally they were of the torrential type. There was nothing to do but advise people to get ready for general floods.

Of course there were warnings issued for all these floods before they began. As the rains kept on the Weather Bureau soon found it necessary to issue additional warnings every two or three days for the lower Mississippi, from Cairo to its mouth, that still higher stages than those previously forecast would be reached. About April 13 the Weather Bureau found that every indication pointed to the greatest flood in the history of the lower Mississippi Valley, and at once bulletins were issued to that effect, warning everybody interested to take all possible precautions to protect life and property. These warnings were later repeated and emphasized, and since that time the Weather Bureau has issued daily advices of stages to be expected and the time when they would be due. Beginning at Cairo it has been possible to make predictions of flood stages nearly a week in advance, and on going down the river warnings have been given at gradually increased periods, in advance. On April 2, the Vicksburg district was advised that the crest of the flood would be reached by the end of April. People at New Orleans were advised on April 8 that the crest would be reached there during the first week in May, and at the same time the probable crest stages were given. Later rains made it necessary to increase the forecasts of crest stages and to delay the dates thereof by 5 to 10 days. Otherwise there has not been much change made in the forecasts.

Thus far the flood has exceeded all previous records from Cairo to Vicksburg, and with the additional rise that began April 27 at Vicksburg from the overflowed waters of the Yazoo basin, the stages below that point will yet exceed all previous stages except possibly where extreme corrective measures may be taken to prevent it. Previous to this flood the 1922 flood was the greatest flood except between Cairo and Memphis, where the 1913 flood was slightly higher. Before 1913, perhaps, the greatest flood was in 1882, although then the levee system was not nearly so extensive as at present, and a much greater area of land was subjected to natural overflow.

During the present period there has also been a great flood in the Arkansas River with stages above all records at Little Rock, and great flood in the Neosho River, a rather severe flood in the Osage River, in the Missouri from Kansas City eastward, and another great flood in the Illinois River, almost as great as the record-breaking flood of October. During the present month the Mississippi River from the mouth of the Des Moines River to Cairo has also been in flood with a stage a little over 36 feet at St. Louis on April 26, the highest since 1903.

Opportunities for Architects and Engineers

Washington, D. C., May 15, 1927.—The United States Civil Service Commission states that it has not received enough applications for positions of architects and engineers to meet the needs of the Supervising Architect in connection with the $165.000.000 public buildings program recently authorized by Congress.

Examinations are open for assistant architects, associate architects, assistant structural engineers and assistant architectural engineers. Entrance salaries range from $2,400 to $3,000 a year. Higher-salaried positions are filled through promotion. Applications for the positions named will be received by the Commission until June 30.

A number of buildings in various parts of the country are under construction and plans are being made for others.

Of the $165,000,000 authorized, $50,000,000 is to be spent in Washington, D. C., for much needed buildings. It is expected that the next Congress will authorize the purchase of the entire triangle between Pennsylvania Avenue and the Mall, approximately a mile in length, for the erection of public buildings along the south side of Pennsylvania Avenue from the Capitol to the Treasury. The consummation of this plan will make Pennsylvania Avenue a grand boulevard, as it should be.

Railroad Earnings

The railroads of the United States have reached a turning point in their history, and the year 1926 definitely opened up a new chapter in their development in the light of a study of the operating records of Class I roads made by the National Industrial Conference Board, covering the period 1920 to 1926. It was during the latter year that the combined earnings of Class I railroads for the first time since the passage of the Transportation Act reached the level of "fair returns" as defined by the "recapture of earnings" clause.

Not the mere fact that the roads as a whole, in 1926, earned slightly above the 5.75 per cent on the government's "fair valuation" of their capital investment, but the manner in which this was achieved is what deserves emphasis. A consistent drive for greater operating efficiency with, at the same time, lower costs has been the keynote of the carriers' program since 1920, when the railroads were restored to private management after four years of government administration. More business, handled at smaller cost per unit, has been the objective, and the degree of success reached is partly reflected in the fact that in 1926 the roads loaded 18 per cent more cars, although they had 12 per cent fewer employees and increased their total freight ton-mileage, that is the total hauling of freight for revenue, by 8 per cent. Ton-miles of freight hauled in 1926 per 1,000 pounds of fuel consumed were 27 per cent greater than in 1920. Total operating expenses, amounting to $5,828,000,000 in 1920, were reduced to $4,669,000,000 last year.

This, moreover, was accomplished on the whole without curtailing wage earnings, which are higher now than they were at the beginning of 1920. While railroad wages, like all other wages and the general price level rose sharply during the latter part of 1920, which was the peak of the post-war inflation period, they dropped again in 1921 and 1922. Since then, however, and while the roads were working out their program of economy and increased operating efficiency, hourly earnings of railroad workers have steadily increased and in 1926 averaged about 7 per cent more than they did at their low level in 1922.

Larger engines, longer trains, more intensive utilization of equipment and many other similar measures were employed to reduce operating expenses while at the time transportation requirements steadily increased. That policy in many cases required large capital expenditures which totalled more than five billion dollars.

The combined earning power of the railroads increased from 0.09 per cent on the total property investment in 1920 to 5.13 per cent in 1926. On the basis of the Interstate Commerce Commission's "fair valuation," which is below the roads' own appraisal of their property investment, they earned 5.99 per cent in 1926, or slightly more than the "fair return" as defined by the Transportation Act. However, the average for the six years would be far below "fair return."

Structural Steel Board of Trade of Philadelphia

This is a new organization, its object being to reduce building cost to the owners of new structures by adopting terms under which the work to be done is clearly set forth in the preliminary proposal and contracts, by giving to the fabricators of structural steel fully dimensioned drawings and by eliminating unfair clauses in contracts hitherto imposed upon steel fabricators.

Recently the members were addressed by Dr. Herbert W. Hess, Professor of Merchandising at the Wharton School of Finance and Commerce, University of Pennsylvania.

In the course of his address, Professor Hess explained that modern trade associations represent a progressive development among business enterprises and have come into existence largely as a result of business men recognizing the advantages accruing from intelligent co-operation, without in any wise destroying the incentive of fair and just competition. This Board, like other trade associations, has been organized primarily for the purpose of standardizing trade practices, and of securing sounder and more efficient methods in the fabricated steel industry through the collection and distribution of trade information. Relations between the fabricators of structural steel on the one hand, and the engineers, architects, and contractors on the other hand, have been heretofore, rather unsatisfactory because of unbusinesslike and predatory practices characteristic several decades ago.

The benefits issuing from such a trade association as the Structural Steel Board of Trade will be reflected in cheaper construction costs and a more balanced building program, both of which will be beneficial to the public.

Cooperative Research Fellowships Offered by Mining Schools

Excellent opportunities for training in methods of scientific research along mining and metallurgical lines are afforded by a series of fellowships offered by a number of leading educational institutions for work in cooperation with the United States Bureau of Mines, Department of Commerce, covering the educational year 1927-28. Students holding these research fellowships are assigned to assist in the solution of certain problems on which members of the technical staff of the Bureau of Mines are working, and the successful completion of their tasks makes them eligible for various degrees. Students receiving this highly specialized training are in considerable demand in the industrial world.

NEW BOOKS

BOOK REVIEWS

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Technique of Executive Control—By Erwin H. Schell, Member of the Faculties of the Harvard Graduate School of Business Administration and the Massachusetts Institute of Technology. 143 pages, 5½ x 8. $1.75.

Success in executive conduct is increasingly requiring intensive and penetrating thinking. Yet few fields of effort have so definitely resisted a rational approach. There has seemed little that is tangible or concrete in the art of executive leadership and vague terms such as "personal magnetism" or "radiating personality" have thrown a spell of enchantment over the processes of human control.

This book offers a concrete analysis of the problems that confront the executive in his relations with his subordinates, associates and superiors. Practically every factor which is at all likely to affect "getting the work done" is given a clear and meaty discussion—and, in each instance, the most valuable kind of suggestions are made for the turning of that factor to the very best advantage.

Four Lectures on Relativity and Space—By Charles P. Steinmetz, Late Chief Consulting Engineer, General Electric Co. 130 pages, 6x9, illustrated. $2.00.

Dr. Steinmetz's book aims to explain the theory of relativity to the engineer, to give him by analogy, example and comparison a general conception of the theory and its fascinating deductions and conclusions, and to do this without resort to intricate mathematics.

Reinforced Concrete Construction—By George A. Hool, Professor of Structural Engineering, University of Wisconsin. New Third Edition. 380 pages, 6 x 9; 139 illustrations. $3.50.

A thorough revision of this standard text for engineering colleges and reference work for engineering offices. It presents in clear, concise form the fundamentals of reinforced concrete construction. In this edition chapters have been added on shear and moment considerations in continuous beams, on simple rectangular flat slab floors and on simple column footings. The chapter on bending and direct stress has been extended.

Kinetic Theory of Gages—By Leonard B. Loeb, Associate Professor of Physics, University of California. 555 pages, 6 x 9; 76 illustrations. $5.50.

A text and reference book combining classical deductions with recent experimental advances in a convenient form for student and investigator. A feature of the book is the complete summary and discussion of the kinetic theory of low-pressure phenomena. Noteworthy also are the discussions of the applications of the kinetic theory methods to two recent fields of research, that of dielectric and magnetic phenomena in gases and that of gaseous ionization.

Fundamentals of Welding—Gas, Arc and Thermit—By James W. Owens, Welding Aide, Norfolk Navy Yard. 672 pages, 279 illustrations. $10.

A complete manual and encyclopedia covering every step and every phase of every branch of the art of welding—the only book that covers all kinds of welding—gas, arc, thermit and resistance.

Electric Power Transmission—By Alfred Still, Professor of Electric Engineering, Purdue University. New Third Edition. 412 pages, 6 x 9; 139 illustrations. $4.00.

The book has been rearranged and revised and, to a large extent, rewritten. The additions have to do mainly with calculations for the design of the longer extra-high-pressure transmissions which are the outcome of rapid developments during the last few years. Like the two preceding editions, the book covers the fundamental principles and calculations from the viewpoint of the engineer responsible for the design and specification of long distance lines.

Water Power Engineering—By H. K. Barrows, Professor of Hydraulic Engineering, Massachusetts Institute of Technology, Consulting Hydraulic Engineer. 734 pages, 6x9, 306 illustrations. $6.00.

A sound and authoritative treatment of principles and practice underlying the design of modern hydroelectric developments. Many new features in the way of diagrams and tables are included, as well as cost data of the more important features of developments. The descriptions of modern hydroelectric stations and their equipment are especially valuable.

Practical Radio Construction and Repair—By James A. Moyer, Director of University Extension, Commonwealth of Massachusetts, and John F. Wostrel, Instructor in Radio, Division of University Extension, Massachusetts Department of Education. 319 pages, 5½x8, 157 illustrations. $2.00.

A practical book for the amateur constructor who wishes to make his own receiver; for the person who buys a commercially built receiver and wants to know how it operates, how to improve it and how to repair and keep it in repair; and for the radio dealer and his assistants who are called upon to test and repair radio broadcast receivers. The treatment is concise and eminently practical.

The Practice of Lubrication, New Second Edition—By T. C. Thomsen, Managing Director Aarhus Oil Works, Ltd., Denmark, for many years Chief Engineer to the Vacuum Oil Co., Ltd., London. Late Research Engineer to the Anglo-Mexican Petroleum Co., Ltd. 616 pages, 6x9; 228 illustrations. $6.00.

A new revised second edition of this standard handbook of practical lubrication. In addition to presenting for each type and class of engine or machinery the "technical background" necessary to focus the lubricating problems and to determine the character of the oils required to give the best service, the book points out the conditions under which lubricants have to work for particular types of machinery and the influence to which they are subjected during use.

This new edition gives viscosities of typical oils, not only in Saybolt, but in Redwood, Engler and Centipoise. Reference is made to experimental research in regard to oiliness of lubricants, a problem which is much under debate. Brief descriptions of centrifugal purifiers and their application in connection with the lubrication of steam turbines, Diesel Engines and transformers are also given.

Electrical Machine Design—The Design and Specification of Direct and Alternating Current Machinery—New Second Edition. Alexander Gray —revised by Prof. P. M. Lincoln, Director, School Electrical Engineering, Cornell University. 523 pages, 239 illustrations. $5.00.

Prof. Lincoln says in his preface: "Although there has been considerable change in the resulting machines, no change has taken place or can take place in fundamental principles. In his presentation of these fundamental principles and in his methods of analysis Gray was unexcelled. No attempt has been made in this revision to make any modification in the methods of analysis that were so ably put forward by Gray in his first edition.

Employment

We receive many inquiries for engineers—civil, mechanical, electrical, production, sales, etc. No fees are charged. Address **Employment Bureau**, care Engineers and Engineering, 1315 Spruce St., Philadelphia.

Advertising inserted under this heading 50 cents a line.

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WANTED, DRAFTSMEN AND DESIGNERS, experienced on machine or tool work for large automotive plant in Eastern Pennsylvania, permanent work. Please reply with full particulars in first letter, including salary wanted. Box E-1361.

WANTED, MECHANICAL DRAUGHTSMAN, with several years' experience in automobile engine design. Box E-1360.

MEN AVAILABLE:

M. I. T. Graduate in electrical engineering, 3 months' power plant construction, 8 mos. distribution, 8 mos. report writing with consulting engineers, wishes position with moderate sized contracting company. Will also consider salespower or engineering equipment. Box A-890.

SALESMAN. Familiar with use and application of tools and steels. Have successful record selling Pneumatic Tools. Box A-889.

ELECTRICAL ENGINEER desires position as Industrial Power or Maintenance Engineer. Six years' experience in Industrial plant engineering. Age 28. Box A-891.

MECHANICAL ENGINEER, grad., 3 yrs. exp., desires position. Will travel or consider design, production, sales. Box A-892.

ELECTRICAL DESIGNING ENGINEER, E. E. graduate, industrial and sub-station design experience, mathematician, desires part time work, afternoon and evening. Box A-893.

GRADUATE MECHANICAL ENGINEER, Power Plant Engineering, Drexel Institute Evening School, desires position as assistant to advertising or sales manager. Adept in handling correspondence. Ten years' experience. Age 27. Can furnish good references. Box A-894.

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MECHANICAL ENGINEER, graduate Baltimore Polytechnic Institute and Johns Hopkins University. Experience: 4 years testing and operating marine and stationary; 1½ years steam turbine design. Desires position doing design and test work. Box A-897.

METALLURGIST-CHEMIST, with experience in making sand, chill, chill pass and alloy steel rolls. Can analyze iron, steel and oil. Knowledge of heat treatment and microscopic work. Desires connection. Box A-898.

MECHANICAL ENGINEER, graduate, 3 years' experience Eng. Dept. large industrial company, mfrs. power plant apparatus. Thermodynamic work; desires work along line of heat engineering. Consider design, drafting, traveling. Box A-899.

RECENT GRADUATE desires position as junior engineer with company manufacturing mechanical equipment or steel fabricating company. Box A-900.

RECENT GRADUATE, mining and metallurgical engineer, desires position as assistant in ore dressing mill. Box A-901.

STRUCTURAL DRAFTSMAN, Structural Engineer Graduate, Drexel Evening School, 3 years' experience on detailing and some designing, desires position with an engineer or construction company. Age 24. Can furnish good references. Box A-902.

GRADUATE STRUCTURAL ENGINEER, would like to connect with general contractor. Has had varied field and office experience. Available immediately. Box A-903.

ESTIMATOR OR SALES ENGINEER, 15 years' general engineering experience on power plant machine design and power house equipment. Desires connection in above lines. Box A-904.

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CIVIL ENGINEER. Young man studying civil engineering through the I. C. S. who can run transit and level, desires position with engineer. Have worked in construction work. Will travel if necessary. Box A-906.

PNEUMATIC CONVEYOR WORK. GRADUATE ENGINEER with six years' experience, designing, detailing, drafting, etc., wishes connection along this line; or will consider sales work with pneumatic conveyor concern. Box A-907.

SALES ENGINEER, graduate, 8 years' selling experience among architects, contractors, etc., desires connection or will consider agency for product in Phila. territory. Box A-908.

SALES REPRESENTATIVE in building material or allied lines desires agency for Phila. territory (graduate engineer). Will consider connection as sales engineer. Box A-909.

ENGINEER, MECHANICAL, good designer, desires erection work or machinery installation, 25 years' experience, can follow work through to completion. Box A-910.

MECHANICAL ENGINEER with experience in piping layout, refrigerating, plant maintenance, detailing, drafting, etc., desires work along above lines, or will take sales work, or estimating on large machinery or power plant work. Box A-911.

GRADUATE CIVIL ENGINEER, Jun. Am. Soc. C. E. Age 28, single. Four years' experience in design, drafting, inspection and field work on varied concrete and steel construction and layouts. Desires position in field engineering or both field and design. Box A-912.

GRADUATE MECHANICAL ENGINEER. Age 28, with experience in research, report writing and acceptance tests, desires permanent location in Philadelphia or Camden. References furnished. Box A-913.

YOUNG GRADUATE ELECTRICAL ENGINEER desires position where knowledge of radio circuits can be used. Night school graduate. Seven years' experience with national electric concern on test work. Single, 25 years. Will go anywhere within 100 miles of Philadelphia. Box A-914.

CIVIL ENGINEER. Experience in railway and highway construction and maintenance, industrial building construction. Age 39. Desires field work. Assoc. Member A. S. C. E. Box A-915.

CONSULTING AND SALES ENG., Mech. and Elec. Eng. Deg., age 37, single, 17 yrs. exp. covering: Factory elec. apparatus and turbine test; cent. station eng. and commercial work. Public Util. oper. and const. eng. and super., cons. eng., steam power plant and equip., invest. and report work. Box A-916.

SALES ENGINEER, graduate Mass. Inst. of Tech., desires connection selling where engineering training and experience can be used. Has had executive and practical mechanical exp. on gas engines and selling exp. on motor trucks. Box A-917.

EXPERIENCED CHEMICAL ENGINEER, age 35, desires sales position, local or traveling, good references, energetic, resourceful; personality. Services available now for permanent connection with well established firm. Box A-918.

ELECTRICAL ENGINEER wishes permanent position in or near Philadelphia. Has ten years' experience in design, purchase and installation of electrical power and distribution equipment for industrial purposes. Box A-919.

JUNIOR ENGINEER with structural engineering and architectural drawing experience, desires work along building construction or other lines either in office or field. Box A-920.

CHEMICAL ENGINEER, 27 years of age, graduate U. of P., 2 years' combustion and power plant experience, 1 year heating and ventilation. Ambitious. Box A-921.

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CIVIL ENGINEER—14 years' experience on construction projects such as municipal engineering on sewers, roads and pavements. Designing, estimating and calculating on survey work, etc. Capable as chief of party. Box A-923.

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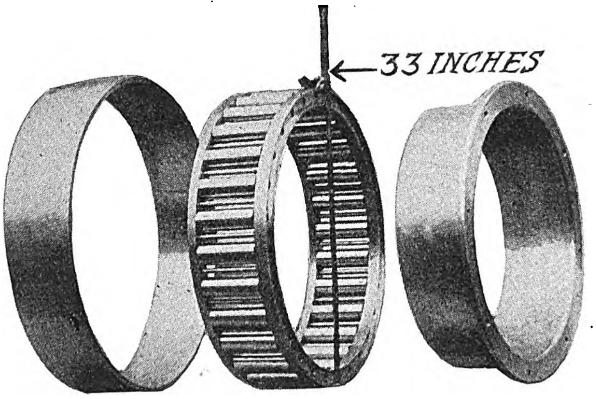

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JUNE, 1927

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Registration of Engineers in Pennsylvania

The following copy of the Act recently passed by the Legislature of Pennsylvania providing for the registration of professional engineers practicing in all of its branches, including surveying, has just been released for publication. We are giving this in full, believing that it will be of interest and value to engineers throughout the United States because many of the States have in force laws requiring registration of engineers and other States are considering the passage of such laws.

AN ACT

Regulating the practice of the profession of engineering in all of its branches, including surveying, providing for the registration of certain persons practicing or offering to practice said profession, conferring certain powers and imposing certain duties upon the State registration board for professional engineers, upon the court of common pleas of Dauphin County and providing penalties.

Section 1 *Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania in General Assembly met and it is hereby enacted by the authority of the same* That in order to safeguard life health and property, any person practicing or offering to practice the profession of engineering in any of its branches, including surveying, shall hereafter be required to submit evidence that he or she is qualified so to practice and shall be registered as hereinafter provided, and it shall be unlawful for any person to practice or to offer to practice the profession of engineering in any of its branches, including surveying, in this Commonwealth unless such person has been duly registered or exempted under the provisions of this act.

Nothing in this act shall be construed as requiring a certificate of registration for practicing the profession of engineering in any of its branches, including surveying, by any person, firm, copartnership or corporation upon property owned or leased by such person, firm, copartnership or corporation unless the same affects the public safety, or health, or the property of any other person, firm, copartnership or corporation.

Section 2 **Definitions.** The term "professional engineer" as used in this Act shall mean a person who through technical knowledge gained by education or by experience in one or more branches of engineering, including surveying, initiates, investigates, plans and directs the control of the forces of and the utilization of the materials of nature and of human activities in connection therewith for the benefit of man, and who represents himself or herself to be such a professional engineer either through the use of the term "professional engineer", with or without qualifying adjectives, or through the use of some other title implying that he or she is such a professional engineer.

The term "surveyor", as used in this Act, shall mean any person engaged in that branch of engineering known as "surveying" who makes surveys for the determination of area or for the establishment or reestablishment of land boundaries or the sub-division and platting of land, who makes surveys for the establishment of lines or grades or elevations for carrying out engineering work including the preparation of plans or specifications for minor engineering work not involving safety to life, and who determines quantities or who makes estimates for proposed work, or for work under construction, or work that is completed, or, who in addition to the foregoing, makes estimates of quantities of mineral or minerals in place or that have been removed.

The term "board" as used in this Act shall mean the State Registration Board for Professional Engineers.

Section 3 **Record of Proceedings—Register of Applicants.** The board shall keep a record of its proceedings and a register of all applications for registration which register shall show such information as may be deemed necessary by the board.

Section 4 **Certificates of Registration—Qualifications of Applicant.** The board, upon application on the form prescribed by it and upon the payment of a fee of twenty dollars, and except as hereinafter provided, shall issue a certificate of registration to the following persons to wit:

(a) Any person who submits evidence that he or she is fully qualified to practice the profession of engineering in any of its branches, including surveying, or

(b) Any person submitting evidence satisfactory to the board who holds an unexpired certificate of registration issued to him or her by any proper authority in the District of Columbia, or in any State or Territory of the United States, or in any province of the Dominion of Canada, in which the requirements and qualifications for obtaining a certificate of registration to practice the profession of engineering in any of its branches, including surveying, are not lower than those specified in this Act.

Provided: That no person shall be eligible for registration under this section who is not a citizen of the United States or of the Dominion of Canada, or at least twenty-one years of age, or who does not speak, read or write the English language, or is not of good character or repute, or has not been actively engaged for at least the minimum number of years hereinafter specified in the practice of the profession of engineering in any of its branches, including surveying, of a character satisfactory to the board and, Provided: That each year of teaching, or of the study of engineering in a school or college satisfactory to the board, shall be considered as equivalent to one year of active practice, but the total number of years of study and teaching which may be credited to active practice shall not exceed four years nor shall the additional active practice in the profession of engineering be less than four years and

Provided: Further, that the board shall register, upon the payment of the renewal fee provided in this Act, and shall issue a Registration Card for the year 1927 to each person surrendering to it an authentic Registration Card for 1927 or 1926 issued by the State Board for Registration of Professional Engineers and of Land Surveyors, created by the Act approved the twenty-fifth day of May one thousand nine hundred and twenty-one (Pamphlet Laws eleven hundred and thirty-one) entitled "An Act to regulate the practice of the profession of engineering and of land surveying creating a State Board for the Registration of Professional Engineers and Land Surveyors defining its powers and duties, imposing certain duties upon the Commonwealth and political sub-divisions thereof in connection with public work and providing penalties," which Act was declared unconstitutional by the Supreme Court of the Commonwealth of Pennsylvania.

The board after an examination, or receiving other evidence of qualification, as provided in this act shall issue a certificate of registration stating that the registrant is qualified to practice as a professional engineer or as a surveyor. The said board shall cause to be impressed upon each certificate of registration issued under this Act the seal of the Commonwealth of Pennsylvania.

Section 5 **Persons Prima Facie Entitled to Registration.** The following facts established in the application shall be regarded as prima facie evidence that the applicant is fully qualified to practice to wit:

(1) As a professional engineer

(a) Ten or more years of active practice in engineering work, *which may include surveying work, and must include engineering work, other than surveying work of a character indicating that the applicant is competent to be placed in responsible charge of such work,* or

(b) Graduation in engineering from a school or college approved by the board as of satisfactory standing and having a course in engineering of not less than four years and an additional two years of active practice in engineering work, *which may include surveying work, and must include engineering work other than surveying work of a character indicating that the applicant is competent to be placed in responsible charge of such work.*

(2) As a surveyor

(a) *Six or more* years of active practice in surveying work of a character indicating *that the applicant is competent to be placed in responsible charge of such work,* or

(b) Graduation in engineering from a school or college approved by the board as of satisfactory standing and having a course in engineering of not less than four years and an additional one year of active practice in surveying work of a character *indicating that the applicant is competent to be placed in responsible charge of such work,* or

(c) Not less than four years of active practice in surveying work of a character in*dicating that the applicant is competent to be placed in responsible charge of such work* and satisfactorily passing the examination prescribed by the board.

Provided: That upon the filing of an application the Board may investigate the allegations therein contained and if, upon investigation, it believes that the applicant is not competent to be placed in responsible charge of engineering work, or of surveying work, as the case may be, it shall decline to register the applicant, stating its reasons. It shall also be the duty of the board to receive any disqualifying evidence offered by any person or persons ob-

jecting to the registration of the applicant and to refuse registration, if, in its opinion, such disqualifying evidence refutes the prima facie evidence contained in the application.

Section 6 **Furnishing Additional Evidence by Applicant for Registration Examinations.** An applicant for registration, where the evidence presented in the application does not appear to the board conclusive or warranting the issuing of a certificate of registration, may be required by the board to present for its consideration further evidence, and also may be required by the board to take an examination; Provided: That said examination shall not be construed as a substitute for the minimum years of practical experience required by the Act.

Section 7 **Citizens of Foreign Countries.** A citizen of a foreign country who seeks to practice the profession of engineering within this Commonwealth and who has practiced engineering for a period of more than ten years, upon presentation of satisfactory evidence that he is qualified so to practice, may, at the discretion of the board, be granted a certificate of registration as a professional engineer.

Section 8 **Practice of Firms, Copartnerships and Corporations.** A firm, copartnership or corporation may only engage in the practice of the profession of engineering in any of its branches, including surveying, in this Commonwealth in the name of the person or persons connected with such firm, copartnership or corporation, who is, or are, in responsible charge of the design, or of the supervision of the work which constitutes such practice, each of whom is registered as required by this act.

Section 9 **Majority of Board to Pass Upon Application. Return of Half of Registration Fee.** A satisfactory character shall be an essential and a majority vote of the members of the board shall be required to pass upon the qualifications of an applicant for registration under the provisions of this act. Should the board deny the issuance of a certificate of registration to any applicant, one-half of the registration fee deposited shall be returned to the applicant and the remainder retained as an examination fee.

Section 10 **Persons Exempted from Registration.** The following persons shall be exempted from registration under the provisions of this act, to wit:

(a) A person, who is a resident of and has an established place of business in this Commonwealth, who shall have filed with the board an application for a certificate of registration and shall have paid the fee required by this act. Such exemption shall continue only for such time as the board requires for the consideration of the application for registration.

(b) A person, not a resident of and having no established place of business in this Commonwealth, practicing or offering to practice therein the profession of engineering in any of its branches, including surveying, when such practice does not exceed in the aggregate more than thirty days in any calendar year, Provided: Such person is legally qualified by registration to practice the said profession in any of its branches, including surveying, in his or her own state or country in which the requirements and qualifications for obtaining a certificate of registration are not lower than those specified in this act.

(c) A person not a resident of and having no established place of business in this Commonwealth, or, who has recently become a resident thereof, practicing or offering to practice therein for more than thirty days in any calendar year, the profession of engineering in any of its branches, including surveying, if he or she shall have filed with the board an application for a certificate of registration and shall have paid the fee required by this Act. Such exemption shall continue only for such time as the board requires for the consideration of the application for registration, Provided: Such person is legally qualified to practice said profession in any of its branches, including surveying, in his or her own state or country.

(d) An employee of a person holding a certificate of registration in this Commonwealth who is engaged in the practice of the profession of engineering in any of its branches, including surveying, and an employee of a person exempted from registration by classes (b) and (c) of this section, Provided: Such practice does not include responsible charge of design or supervision.

(e) Officers and Employees of the Government of the United States while engaged within this Commonwealth in the practice of the profession of Engineering in any of its branches, including Surveying, for said government.

(f) A person having no established place of business in this Commonwealth, who practices the profession of engineering in any of its branches, including surveying, exclusively, as a regular employee of a public service company as, defined in the Public Service Company Law, by rendering to such company engineering service in connection with its facilities, which are subject to regulation, supervision and control in order to safeguard life health and property by the Public Service Commission of the Commonwealth of Pennsylvania, so long as such person is thus actually and exclusively employed and no longer, Provided: That such company shall have at least one engineer registered under the provisions of this act in responsible charge of such company's engineering work in Pennsylvania.

Section 11 **Renewal of Certificates of Registration.** Certificates of registration shall expire on the last day of December following their issuance or renewal and shall become invalid unless renewed as hereinafter provided. It shall be the duty of the board on or before the last day of November to notify by mail every person registered hereunder of the date of the expiration of his or her certificate and the amount of fee required for its renewal for one year. Renewal may be effected at any time during the month of December by the payment of a fee of one dollar to the board. The failure on the part of any registrant to renew his or her certificate annually in the month of December, as required above, shall not deprive such person of the right to practice the profession of engineering during the year succeeding, but if renewal fee as hereinafter provided is not paid within the succeeding year, the registration shall expire on the last day of December of that year. The fee to be paid for the renewal of a certificate after the month of December shall be increased fifty per centum for each month or fraction of a month that the payment of renewal is delayed, Provided: however, That a certificate of registration, not renewed within one year after it has become invalid, shall thereby be rendered null and void.

Section 12 **Revocation of Certificate of Registration. Procedure.** The board shall have the power to revoke the certificate of registration of any registrant who is found guilty of

(a) The practice of any fraud or deceit in obtaining a certificate of registration or
(b) Any gross negligence, incompetency or misconduct in practicing as a registrant.

Any person may prefer charges of fraud, deceit, negligence, incompetency, or misconduct against any registrant. Such charges shall be in writing and shall be sworn to by the person making the same and shall be filed with the board.

All charges, unless dismissed by the board as unfounded or trivial, shall be heard and disposed of by the board within three months after the date on which they were preferred.

The time and place for said hearing shall be fixed by the board, and a copy of the charges, together with a notice of the time and place of hearing, shall be personally served on or mailed to the last known address of such registrant at least thirty days before the date fixed for the hearing.

At any hearing the accused registrant shall have the right to appear personally and by counsel to cross-examine witnesses appearing against him or her and to produce evidence and witnesses in his or her defense.

If after such hearing three or more members of the board vote in favor of finding the accused guilty of

(a) the practice of fraud or deceit in obtaining a certificate of registration or
(b) Any gross negligence, incompetency or misconduct in practicing as a registrant,

the board shall revoke the certificate of registration of such registrant.

The board, for reasons it may deem sufficient, may reissue a certificate of registration to any person whose certificate has been revoked, provided three or more members of the board vote in favor of such reissuance. A new certificate of registration to replace any certificate revoked, lost, destroyed, or mutilated may be issued, subject to the rules and regulations of the board. A charge of ten dollars shall be made for such issuance. A charge of one dollar shall be made likewise for a reissuance of a registration card.

Section 13 **Appeal to Court when Registration Denied or Revoked.** Any person who shall feel aggrieved by any action of the board in denying or revoking his or her certificate of registration, may appeal therefrom to the court of common pleas of Dauphin County and after full hearing, said Court shall make such decree, sustaining or reversing the action of the board as to it may seem just and proper. The action of said Court shall be final.

Section 14 **Seal of Registrants.** The issuance of a certificate of registration by the board shall be evidence that the person named therein is entitled to all the rights and privileges of a registrant as long as the said certificate remains unrevoked or unexpired.

Each registrant hereunder shall, upon registration, obtain a seal of the design authorized by the board bearing the registrant's name and number and the legend "Registered Professional Engineer" or "Registered Surveyor." The board, at its discretion, may arrange to furnish each registrant with a seal of the design authorized by it and under such conditions as it may establish.

Plans, specifications, plates, and reports issued by a registrant shall be stamped with the seal during the life of the registrant's certificate and it shall be unlawful for any person to stamp or seal any documents if the certificate of the registrant named therein has expired or has been revoked, unless such certificate has been renewed or reissued, and it shall be unlawful to use the seal or a copy thereof for other purposes than herein specified, or a seal of any other design than that authorized by the Board.

Section 15 **Registered Surveyors May only Practice Surveying.** Nothing in this Act shall be construed as permitting a person registered only as a surveyor to practice any other branch of the profession of engineering. Nothing in this Act shall be construed to prevent any person who is qualified under the law to use the title "Registered Architect" from doing such engineering work as is incidental to his architectural work or to prevent any person who is qualified under the law to use the title "Registered Professional Engineer" from doing such architectural work as is incidental to his engineering work.

Section 16 **Penalties.** Any person who shall practice the profession of engineering in any of its branches, including surveying, in this Commonwealth without being registered, or exempted in accordance with the provisions of this Act, or any person presenting or attempting to use as his or her own the certificate of registration of another or any person, who shall give any false or forged evidence of any kind to the board, or to any member thereof in obtaining a certificate of registration, or any person who shall falsely impersonate any other registrant of like or different name, or any person who shall use or attempt to use an expired or revoked certificate of registration, or shall violate any of the provisions of this act shall be guilty of a misdemeanor and shall upon conviction be sentenced to pay a fine of not less than one hundred ($100) dollars nor more than five hundred ($500) dollars or suffer imprisonment for a period not exceeding three months or both.

Section 17 **Provisions of Act Severable.** The provisions of this Act are severable and in the event that any provision thereof should be declared unconstitutional, it is hereby declared that the remaining provisions would have been enacted notwithstanding such judicial determination of the invalidity of any particular provision or provisions in any respect.

Section 18 **Repeal.** All acts and parts of acts of Assembly inconsistent with this Act are hereby repealed.

Prizes for Electric Arc Welding

The Lincoln Electric Company, of Cleveland, Ohio, offers three prizes, $10,000, $5,000 and $2,500, for papers disclosing advancement in the art of arc welding. Anyone, anywhere may compete. Time limit, January 1, 1928. For further information address the custodian of the fund, The American Society of Mechanical Engineers, 29 West 39th Street, New York.

Maps Available Complete U. S. Highway System

Final location of the United States System of Highways consisting of approximately 80,000 miles of most important roads in the coutry have been made known by the Bureau of Public Roads of the United States Department of Agriculture. Public announcement of the exact location of the routes has been withheld until maps could be prepared for distribution.

The system selected embraces ten main transcontinental routes designated by numbers which are multiples of ten while the important north and south routes are numbered 1, 11, 21, 31, etc. These important through routes have many variants and crossovers to other routes, reaching practically all of the larger cities and serving every section of the country.

There will be no difficulty in following any selected route since a standard sign showing the route number has been adopted and also standard danger, caution, and directional signs. These standard signs will add greatly to the safety and convenience of travel as there will be no change in their character in passing from one State to another. Twenty-two States already report their United States highways completely marked, 14 report the work partially complete and 6, which have not yet started, anticipate that it will be completed this season.

Railways of South America

The Department of Commerce, Bureau of Foreign and Domestic Commerce, issued on May 7 a comprehensive survey of the railways in seven South American countries—Bolivia, Colombia, Ecuador, Guianas, Paraguay, Peru, Uruguay, and Venezuela. The increasing interest in investments in South American countries on the part of American capital has accentuated the need of a study covering the chief results of the construction and operation of its railroads.

The present bulletin contains 420 pages and has 28 illustrations and maps, including complete railway maps of the countries covered. Copies may be obtained from any district or co-operative office of the Bureau of Foreign and Domestic Commerce, or direct from the Superintendent of Documents, Government Printing Office, Washington, D. C. The price is 85 cents.

Principles of Boiler Scale Formation and Prevention

A physico-chemical study of boiler-scale formation and boiler-water conditioning has been completed by chemists of the United States Bureau of Mines, Department of Commerce, in co-operation with Carnegie Institute of Technology and industrial interests. This is the first fundamental scientific study conducted, from the viewpoint of the physical chemist, of the mechanism of scale formation and corrosion in steam boilers. The results of the investigation should tend to promote real conservation of fuels and boiler equipment. Fuel losses due to the formation of boiler-scale run into enormous figures. A report containing the results of this investigation has just been issued as Bulletin 24, Mining and Metallurgical Investigations, by Carnegie Institute of Technology.

Need of Modern Port Facilities

By B. HOFF KNIGHT

Manager, Port of Philadelphia Ocean Traffic Bureau

Mr. B. Hoff Knight is a thoroughly practical traffic man; his life work has been devoted to the movement of commerce by rail and water, and it is his primary duty to "sell" the facilities of the port to the shippers of the city and of the country. He is what might be termed a traffic engineer, as it is part of his business to show shippers what we have in the way of handling equipment and what it means to them from the standpoint of dollars and cents. As the manager of the Ocean Traffic Bureau, a combination of all the more important trade and commercial organizations working for the development of the port, he occupies a most responsible position. He will tell us something about the activities of his organization and how Philadelphians are both directly and indirectly affected thereby.

THERE is a very close relation between the traffic and the engineering side of a port.

"Facilities are not commerce," was stated in a very important case before the Interstate Commerce Commission recently, and that is certainly true, because regardless of how good your facilities may be, if the traffic is not passing over them, or they are not being utilized, those facilities are for naught. And there are many things in back of the port which will either make or prevent traffic from moving over the facilities of the port. About four years ago, the Port of Philadelphia Ocean Traffic Bureau was formed for the express purpose of developing greater commerce via the port of Philadelphia. Our first duty was a complete analysis of our markets, to determine what was the logical traffic that should be routed via the Port of Philadelphia, and what percentage of it we were then receiving. That analysis made some very startling disclosures. For instance, for a population of seven millions served direct by the Port, and a potential population of twenty-five millions, the amount of coffee coming in via the port was scarcely sufficient for one morning's breakfast. We studied our facilities; we found that we had some splendid piers especially adapted to the handling of coffee. Coffee is a commodity that requires very careful handling, and the least handling the better. At New York, where it is of necessity handled by lighterage, due to the physical condition of the harbor, there is a great deal of damage and loss due to the breaking of the bags, re-handling, etc. At Philadelphia, we can handle direct from the ship to the cars. The first year only 788 bags of coffee came in through the Port. Last year, over 60% of the coffee consumed in the metropolitan Philadelphia area came in via our own port. In addition to the more expeditious handling, we saved the importers on that coffee many, many dollars by not having to pay the freight charges from New York, as was the case in former times. We established a direct service from South America to Philadelphia with two sailings a month. It is now operating three sailings a month, and two other lines are in the field. Those services have also produced a great deal of other business from South America that never entered the Port of Philadelphia before, such as ores, skins, hides, minerals, etc.

Philadelphia is a great area for the manufacture of cocoa and chocolate,—another commoodity, cocoa-beans, which requires very careful handling. Four years ago, none of the beans came in through Philadelphia. We made a very careful study of that situation. It was practically controlled through financial interests in New York. We made our appeal. At first we had some difficulty in breaking in, but after we demonstrated to the consumers of the beans that we could land them via Philadelphia with less damage, and at a direct saving averaging 9.6c per bag, we got the first shipment, amounting to 1,000 tons. The first year we had 500,000 pounds come in through the Port. For the first two months of this year, the receipts have been over fifteen million pounds. That shows what can be done. There is one importer in this territory who brings in between two and three hundred thousand bags annually, which means a direct saving to that firm alone of between thirty and thirty-five thousand dollars.

I am going to briefly point out what our facilities are doing to help increase our commerce.

At the northern limits of the harbor is Port Richmond. It is the largest single freight unit in the world. It has a capacity of ten million tons annually, and within the Port Richmond area is every facility that a modern port could desire. It has splendid general piers, open piers for the handling of heavy materials, such as steel, machinery, lumber, etc. Those piers are equipped with cranes ranging in capacity from 3½ up to 50 tons. It has a splendid elevator and another under construction, with a total capacity of about four million bushels; has splendid ore handling facilities, capable of handling 250 to 650 tons per hour, according to the grade of ore, and the type vessel being discharged. It has splendid coal facilities, a dumper with a capacity of forty-two cars per hour, coal trestle, and various other facilities, so that in that vicinity there is every facility that a modern port could wish.

Further down, the Reading Railroad also has a group of three piers at the foot of Willow and Noble Streets. Those piers are modern in every detail, and recently one of them, No. 25 North, was reconstructed to provide an apron track on the north side. That apron track permits the handling of cargo to and from open top rail equipment with ship's tackle, without any additional expense involved. This makes the handling of certain commodities as cheap as it is possible to handle them. The city of Philadelphia to date has constructed fourteen modern piers at a cost of about forty million dollars. Those piers are all occupied, and the revenue received therefrom is sufficient to carry all charges, including sinking fund, so that the city's borrowing capacity is in no way impaired by that expenditure. The latest completed is No. 86 South. That is one of a group of four. It is 900 feet long, 336 feet wide, double deck, and has every modern facility, including lower-ators, elevators, chutes, etc. To give you some idea of the area of that pier, the paving required was sufficient to pave Chestnut Street from the Delaware River to past 52nd Street. There are three tracks depressed in the center so that the floors of the cars are at the level of the pier; and two apron tracks, with a total capacity of 85 cars. The Tidewater Terminal below, built by the Government at a cost of thirteen million dollars during the war, the main pier is 1,500 feet long, triple deck, with over one million square feet of covered floor space, with facilities for discharging direct to the upper decks in the event of cargo being placed in storage. That again is a very great saving in the handling of cargo, for if it is landed on the lower deck to take it to the second deck, it would represent perhaps fifty cents a ton in stevedoring charges, and that is more than our freight rate under New York.

The Pennsylvania Railroad have, at Washington Avenue Wharf, a group of piers, seven in number, and at Girard Point, other piers, and also at Greenwich, a coal dumping facility similar to the Reading, with a capacity of twenty-five cars; at Girard Point, a modern grain elevator of two and a quarter million bushels capacity, and ore machines.

The Baltimore & Ohio Railroad use one of the City's piers as their export terminal. These piers are equipped for handling practically every kind of cargo that is moved. For instance, at the open pier of the Tidewater Terminal, they handle tremendous quantities of lumber. They have every facility, and it is interesting to mention within the last three years Philadelphia has shown a higher percentage of increase in the handling of West Coast lumber than any of the other North Atlantic ports.

There have been a great many commodities that should come rightfully to Philadelphia territory through its Port, which have not come in here heretofore, due to the fact that perhaps sufficient interest was not manifested by the importer, but the Port of Philadelphia Ocean Traffic Bureau has taken various countries as units, and we have studied just what the exports and the imports to and from those countries might be. For instance, there is a great movement of flur-spar from England and from various continetal ports. Very little came into Philadelphia direct, although it was used by our various steel mills. In one year we were able to increase our receipts 75,000 tons, and since then the business has been gaining materially each year. The apron tracks at Philadelphia provided that business for Philadelphia. It had formerly been handled via New York, where the expense was very heavy, but a savings of about 50c a ton in stevedoring charges brought the business to this Port. Through the splendid facilities at Port Richmond and Girard Point for the handling of ore, we were able to increase our receipts of iron ore in one year 600,000 tons.

We have splendid facilities for handling import pig iron. We have space available for cheap storage, where it can be placed on the ground. Four years ago scarcely any of the import pig iron came into Philadelphia. For the last four years we have materially gained, and last year we showed an increase over the previous year of 209,000 tons.

The traffic situation, as to rates—ocean, rail and terminal—is a very important factor in the handling of commerce. Until two years ago we never had what is known as a split-delivery tariff. A split delivery provides for carload rate on less than carload shipments for the same destination assembled, placed in one car, and shipped as a carload. Without that tariff, it was necessary for the shipper or receiver to pay the less than carload rate on each individual unit. But under the split delivery tariff, the carload rate is made applicable, and the railroads arrange for the split deliveries for the various destinations to the several piers without additional charge. At the present time, before the Interstate Commerce Commission is perhaps one of the most exhaustive studies of terminal situations that has ever been made. The Interstate Commerce Commission is studying to determine whether there should be through rates to ship side, that is, through rates including the terminal services, or whether there should be a separation as between the line haul and the terminal service charge. The investigation has progressed to the point where the railroads have filed with the Interstate Commerce Commission the actual expenses incurred by their different companies in the handling of cargo at the several ports. New York is the most expensive, averaging $2.75 a ton; Philadelphia is the cheapest, averaging $1.12 a ton. That is a difference of $1.63 a ton in favor of Philadelphia. But all of our rates are predicated on the basis of the New York rate less 40c a ton, so instead of having the full $1.63 a ton advantage, which our natural geographical position entitles us to, by virtue of the rates being predicated on the New York basis less 40c a ton, we only get one-quarter of what we are rightfully entitled to. Philadelphia, in that investigation, is taking the position that there ought to be the separation, in order that there would be reflected in our rates, to the fullest extent, the natural advantages of our geographical position. I believe many of the other ports will take the same position, because as long as our rates are predicated on the basis of the New York rate, every ton of cargo handled over our docks pays tribute to the maintenance of the Port of New York. We are all hopeful that that situation is going to be favorably decided, and if it is, Philadelphia will, in my opinion, then go forward by leaps and bounds; and the only reason we have not gone forward more has largely been due to the rate situation. Our investigation of various terminal situations at competitive ports has disclosed in other ways how the railroads can favor the traffic through one port to the detriment of another.

We have another condition where, on inter-costal business (That has developed to a tremendous volume now, between the East and the West Coast). The railroads in Philadelphia did not absorb the cost of unloading the car after it reached the dock for movement Westward, or after the goods were unloaded from the ship to the dock, loading them in the car for movement to the interior. At other ports they did. We finally, after a great deal of effort, got that situation ironed out, and the first year that arrangement was in effect, our commerce in that particular trade increased 35%.

On West Coast lumber, however, we still are working under some difficulties. At New York, Baltimore and Norfolk, the railroads will absorb the cost of piling lumber from the ship's sling in open top cars. They have consistently refused to do it at Philadelphia. This means that the lumber shipper, or the lumber receiver at Philadelphia must absorb about $1.25 a thousand feet on traffic moving through Philadelphia that he is not faced with at other ports. When you take into consideration that the average profit on West Coast lumber today is about $2.00 a thousand feet, you can readily understand why they kick when they are assessed this $1.25 a thousand feet at Philadelphia, which they do not have to pay at other ports. The railroads have that matter under consideration, and I think that we are going to get a favorable decision. One line has already indicated its desire to go along, but will not act independently, and is awaitnig the word of the other two lines serving Philadelphia. As soon as they can determine their position, which I hope will be favorable, I look forward to a very large increase in West Coast lumber.

Under an old decision of the Interstate Commerce Commission, after a long fought battle, Philadelphia was penalized to the extent of seven cents a ton in rates on coal. Why, nobody has ever been able to explain. Baltimore has a coal rate 7c per ton less than Philadelphia. During the recent British coal strike there were millions of tons of coal moving to the other side, but we could not secure that business, due to that artificial barrier of 7c a ton, until the ports to the South of us were so congested that they could not take on any more business, and then we got the crumbs that dropped from the rich man's table. There was one concern had an item of 200,000 tons of coal for export that they were exceedingly anxious to forward via Philadelphia because they were familiar with our facilities, knew what we could do, and yet they were prevented from using this port due to the fact that this rate of 7c a ton prevailed against us.

Regional Planning Highlights in the Philadelphia District

Samuel P. Wetherill, Jr., President of the Regional Planning Federation of the Philadelphia Tri-State District, recently addressed 35 presidents, engineers and other officials of the larger utilities, banks, trust companies, insurance companies. The group was called together at the invitation of Effingham B. Morris, Samuel Rea and Samuel T. Bodine. A committee was appointed to consider a future program of work and ways and means of continuing regional planning studies on an adequate basis.

On May 2nd, D. C. Stackpole, of the Pennsylvania Department of Highways, and W. H. Giffin, of the New Jersey Department of Highways, met with the Federation's highway committee to discuss studies of seven proposed highways designed to relieve unnecessary traffic congestion. These would divert traffic from crowded centers of Philadelphia, Baltimore, Washington, Trenton, Wilmington and other cities on the line of suggested routes.—E. F. T.

Purchasing Value of the Dollar

The purchasing value of the dollar as measured by living costs for the American wage earner and other persons of moderate means, which includes the great majority of the population, today stands higher than it has for more than two years past, according to the National Industrial Conference Board. The dollar is now worth, on the basis of present living costs, 61.1 cents as compared with the pre-war (1914) dollar. It was lowest in July, 1920, when it stood at 48.9 cents.

The purchasing power of the dollar has been thus enhanced by the steady decline in average living costs throughout 1925 and 1926, which last April, however, were still 63.7 per cent higher than they had been in 1914, just before the war. But the average weekly earnings of industrial workers, owing to higher wage rates and more steady employment, at present are more than twice as high as they were in 1914, so that in spite of the higher living cost, the wage earner on the average draws weekly pay of about 34 per cent greater purchasing power than he did just before the war.

Engineering Side of Pier Construction

By CARROLL R. THOMPSON
Chief Engineer, Dept. of Wharves, Docks and Ferries
Philadelphia, Pa.

Mr. Carroll R. Thompson has been associated with the Department of Wharves, Docks and Ferries for about nineteen years, and for some time prior thereto was with the Pencoyd Iron Works; coming up through the Engineering Department of the Department of Wharves, Docks and Ferries, he was made Assistant Director in 1920, and was later promoted to the office of Chief Engineer. He has had direct charge of and personally handled all the engineering questions arising in connection with the designing and building of those great concrete structures along the City waterfront. They are really monuments to Mr. Thompson's engineering ability. He has played no small part in the development of the municipality's program.

MUNICIPAL PIER No. 80 South Delaware Wharves, now in course of construction near the foot of old Jackson street, on the Delaware River, is selected to discuss some of the Engineering points relating to Municipal pier construction in the Port of Philadelphia.

This structure is one unit of a battery of pier terminals forming what is known as the Upper Group of the Moyamensing Piers, which occupies a 2,250-foot stretch of waterfront along the Delaware River between McKean street and Porter street. As originally planned in connection with the development of the Port under the terms of the South Philadelphia Agreement, the Moyamensing Pier Group consisted of two piers 250 feet wide and two others 300 feet wide, extending 900 feet into the Delaware River to the Pierhead Line. All of the docks or waterways were planned to be 300 feet wide. Along the shore end, approaches to the several piers were provided for by a marginal street 150 feet wide with lateral streets connecting with the new Delaware avenue, which at this locality is approximately 400 feet inland from the piers. The areas between this marginal street (known as River street) and Delaware avenue were to be utilized for car service yards—a necessary adjunct to any marine terminal of the size of the Moyamensing Group to provide sufficient car service for its operation to full capacity.

The first active step by the City towards constructing this Terminal was taken in 1915 with the building of the upper pier, No. 78 South at the foot of McKean street. It was rushed to completion during the war period and was utilized by the U. S. Government in connection with overseas shipments, and has been intensively used for commercial purposes ever since. While the war temporarily interrupted the City's building program in South Philadelphia, construction was resumed on the two lower piers, Nos. 82 and 84, immediately after the close of the war. The substructure of Pier 82 is now built and the most southerly pier of the group—No. 84 South—was finally completed and put in operation about a year and a half ago.

No radical modification of the original layout has been made since its adoption. The new Pier 80 will be built 1,000 feet long instead of 900 feet, which increase in length was readily accomplished by digging inland without in any way destroying the general layout or plan of operation. Apron tracks have been built along each side of Pier 84, which increased the over-all width from 300 feet to 336 feet, and the new Pier (No. 80) will have a width of 280 feet instead of 250 feet. This latter increase in width was also adopted to provide apron tracks without decreasing the size of the pier shed.

When finally completed, this Moyamensing Group of four piers—ranging in width from 250 feet to 336 feet—will have 8 ship berths: five 900 feet long and three 1,000 feet long; and will provide accommodations for 16 ships in docks 285 feet wide.

Some years ago a very complete analysis of the cost of modern pier construction to meet the conditions prevailing in the Port of Philadelphia, together with actual bids on several different types, indicated clearly that where the pier width was more than 200 feet the "solid-fill" type of structure would be the cheapest. This type may be briefly described as a concrete and timber bulkhead built around the three sides of the structure to retain a core fill which forms the main body of the structure.

The other types considered in this analysis included the "Cross-Wall" type, and a modification known as the "Cross Beam," both of which are concrete structures supported on timber pilings; and the "Pile-on-Platform" type, which consists of a timber deck on timber piles that support a fill retained by concrete walls built around the edges of the wharf.

The three substructures of the Moyamensing Piers already built—Nos. 78, 82, and 84—follow the "Solid-Fill" Type.

Unfortunately, however, with this type, the filling between the bulkheads, which finds its support upon the river bottom and may vary in depth from 15 to 25 feet, is subject to considerable settlement over a period of years. When this takes place the pier deck becomes uneven and considerable difficulty is experienced by the pier operators in their trucking operations. In the course of a few years it is necessary to tear up the deck paving, restore the deck to its original elevation by additional filling, and then to repave. This is one of the disadvantages of the "Solid-Fill" type of construction, which becomes very serious when the restoration of the deck must be undertaken while the pier is in use. The delays to shipping on an intensively used terminal, and the high cost of repairs under such conditions, are obvious.

In the Pier 80 substructure work, two types of construction will be used. The inshore half will be built over a site that was reclaimed by filling-in some 25 years ago. As this reclaimed area has had ample time for final settlement to take place, the portion lying within the lines of the pier will be retained by relieving platform bulkhead construction, which will also form the sides of the pier; or in other words, the "solid fill" type of construction will be used. Riverward from this old filled-in section, the structure will be built of the "Fill-On-Platform" type. The timber deck built near the low water level will extend over the entire area of the outshore section of the pier and be supported by timber piling. Around the edges of this timber platform, or sub-floor, mass concrete walls will retain a fill deposited on the timber deck and brought to the level of the main pier deck. This entire construction is therefore a combination of the "Solid-Fill" type and "Fill-On-Platform" type, and should prove to be more satisfactory than the full "Solid-Fill" type used for the other piers.

As the filling-in of the outshore section over the timber deck will result in a fill of not more than 12 feet in height, it is to be reasonably expected that it can be compacted sufficiently so that no objectionable depressions in the finished deck will occur.

Generally, the "Fill-On-Platform" type of substructure construction would appear to be the preferable type to meet conditions that exist in Philadelphia. The filling naturally distributes any live loading over a large supporting area; the pier water-supply lines may be placed in the fill where they will not freeze; railroad tracks may be placed in any location on the pier without providing special supports for them; and any future alterations that may be required to the pier deck can be more readily and more cheaply made than in any of the concrete types.

The pier-shed construction will follow the usual "Philadelphia" design, which is a form of Mill Building construction in structural steel, modified to suit pier-shed use. It will be two stories in height and be built of long span construction. The purpose of the long spans is to decrease the number of supporting columns, which gives less obstructions to the free movement of traffic and the handling of cargo within the shed. While this reduction in the number of columns in comparison with former structures requires heavier upper deck steel-work, the resulting increase in cost is well worth while, when the freedom with which cargo can be handled in such a shed is taken into account.

For the interchange of freight between the two decks, standard electric freight elevators will be installed, together with gravity chutes for lowering cargo from the upper deck to the lower deck. To eliminate any necessity of teams and trucks going on the lower deck of the pier for freight that has been discharged or stored on the upper deck, large auto-truck elevators will be built at the street end of the shed so that local delivery vehicles may reach the upper deck directly from the street approaches. The importance of keeping as many teams as possible off the first deck cannot be over-emphasized, as it is these transportation units that cause most of the confusion and congestion within the sheds.

Railroad tracks upon the upper deck would also greatly increase the efficiency of a two-story pier shed, but the adopted grades and locations for railroad trackage under the terms of the South Philadelphia Agreement seem to prevent any possibility of realizing track installations of this character within the pier sheds in Philadelphia.

Like Pier No. 84 South, the new Pier will be equipped with three shed tracks, extending the full length of the structure in a sunken pit along the center line. Cross-overs located near the center of the length of the pier and connecting the center track with the other two or storage tracks, will enable car service to be supplied to the outshore berths without disturbing any cars that may be placed opposite the inshore berths. Along each side of the pier shed, apron tracks will also extend the full length of the structure and will permit the direct loading of imperishable freight between car and ship. These tracks will be laid flush with the pier deck, which will allow the full width of the apron to be used, when not occupied by cars, for the making up of drafts of cargo. Sufficient space—about 7 feet—has, however, been provided between the side of the cars and the pier shed, so that ship loading and discharging can be conducted to the pier deck even though cars may be temporarily placed on the tracks.

To supplement the ship's gear in loading and discharging ships, the customary cargo masts will be installed. As the system of "burtoning" with the ship's winches, by means of the cargo masts on the pier and the booms on the ships, is still the preferred method of loading and discharging general cargo, and also is apparently the most flexible method for this class of cargo, wharf cranes will not be installed.

Continuous door openings in the first story will extend along the full length of each side of the pier, and in the second story alternate bays will be equipped with doors. With this design, ship-loading operations may be conducted to either deck at any point along the ship's berth.

In discussing further the "Philadelphia" design for transit sheds: Every effort should be used to follow the requirements of fire-proof construction, where they can be applied. The roof should and can be built of fire-proof materials. Wood sheathing and the standard tar and slag weather-proofing, in many respects, form an excellent pier roof, but it does not meet fire-proof requirements. Concrete roofs, while fire-proof, add considerable dead load to the building and are costly. Structural gypsum roofs, weather-proofed with any of the acceptable roof coverings, meet all the necessary fire-proof requirements, and this roof is a desirable type on account of its light weight.

Fire curtain boards, located about every 100 feet longitudinally with the pier and built of corrugated sheet metal extending from the underside of the roof sheathing to the bottom of the roof trusses completely across the pier, can be installed at small expense, and, in the event of fire, will effectively prevent flames from traveling along the roof.

All stairways and elevator shafts, etc., should be enclosed with fire-proof walls and openings in the second deck floor for chutes, and hatches closed with metal doors. The side walls of the pier shed should be built of brick or other fire-proof materials, that possess sufficient stability to withstand impact from striking drafts of cargoes during ship loading or discharging operations, and all cargo doorways should be closed with an acceptable type of fire retardant door, built and designed expressly for pier sheds.

Fire walls within the shed are always objectionable, except, possibly, where a pier may be used *exclusively* for marine-rail freight, or where local delivery traffic does not enter into the terminal operations at all. Such cases, however, are very rare.

Efforts have been made from time to time to encase the structural steel work of pier sheds with a fire protection material, but invariably the cost of so doing has been excessive in addition to adding considerable dead weight to the structure, and it is generally conceded that the financial returns from harbor facilities will not justify the extra cost.

Fire protection interests generally object to high ceilings. With a two-story shed, however, a high second deck is a necessity. Sufficient overhead clearance must be provided for drilling railroad cars in and out of the shed, and a minimum clear height of 22 feet is an operating regulation of the Railroads. The high first deck door opening—usually in the neighborhood of 20 feet—is also essential for ship loading and discharging, particularly when the pier aprons are of the narrow type. Ample size door openings must be provided to allow loading and unloading when the ship is light, and tidal variations must be taken into account. At Philadelphia, where the main deck is customarily built from 10 to 14 feet above mean low water, a door opening height of 22 feet is desirable. For the second story, about 17 feet are necessary. It is obvious that these requirements for cargo door openings and car clearance determine the story height.

Any upper story floors should naturally be built of fire-proof materials, and reinforced concrete not only fulfills this requirement but also is very suitable both structurally and economically.

There seems to be a substantial agreement among Port Engineers regarding the allowable floor loads for which general cargo pier sheds should be designed. A live load of 600 pounds per square foot for the first deck and 300 for the second story are the accepted standards. A fair average of the deck area required for handling and temporarily storing one-ton of cargo is 10 square feet. Some investigations at Philadelphia, which were confined to a small number of piers, indicate that 13 to 15 feet is more nearly correct, although no claim can be made that these figures represent an accurate average of the entire freight handled at the Port of Philadelphia. This estimate however of the average, and taking into account the necessity for providing for heavier loading, which occurs quite often, and also heavy concentrations for auto-truck traffic, indicates a correct assumption for the first deck.

With a more extensive installation of vehicular elevators to permit local deliveries reaching the second deck, it may be advisable to increase the second deck load to more than 300 pounds.

The adoption of the large, unobstructed cargo deck area is the fundamental essential for the successful operation of a general cargo pier terminal, and the width of the structure is the most important factor in its layout. For economy, cargo handling over the pier must be conducted within the length of the ship berth,—hence the importance of ample width. Increasing the length of a pier to obtain cargo working space would increase trucking distances and lead to narrow pier construction, with its consequent confusion and congestion. Freight movement in the pier shed should be as nearly straight across the pier as possible.

Several theories have been advanced from time to time for determining pier widths, by basing calculations on the length of ship berth, the ship's tonnage, and assuming a "temporary storage" factor of pier deck area required for one ton of freight piled to the customary height of six feet—usually ten square feet per ton. While such rules are helpful as a basis for investigation, they can not always be accepted as a standard applying to all general cargo piers. Local conditions will greatly influence the result. The percentage of car freight that is removed from the pier during ship discharging will not only vary at different ports, but may also vary within a port. The amount of lighterage freight will have a bearing upon the pier width, as will also the amount of local delivery freight.

At Philadelphia, where the marine-rail freight movement constitutes about seventy-five per cent of the total, a 200-foot width of pier for effectively handling the cargo of two modern freight carriers over a two-story structure, is regarded as ample for the double pier, which berths one ship on each side. This size provides for an apron 7½ feet wide outside of the shed and two depressed railroad tracks occupying a space 26 feet in width along the axis of the pier within the shed, and was determined upon as fulfilling Philadelphia's port requirements after a study of general operating conditions in the Port, supplemented by observations of congestion on narrow piers in other ports as well as that experienced on narrow piers in Philadelphia.

Each track laid on a pier requires a space of approximately 13 feet, and where apron tracks are desirable, the pier width should be increased approximately 30 feet. It is not good policy to reduce the width of the pier shed for the accommodation of apron tracks.

With the multiple-berth pier—which will accommodate two or three ships on each side—it is obvious that local deliveries must pass through the inshore end of the pier to reach the outshore berths, and therefore, to avoid interference and congestion, the pier width should be increased. It is not uncommon for all berths at this type of pier to be occupied by ships loading and discharging cargo simultaneously, and the necessity of providing sufficient width to permit land transportation to reach the cargo decks of each berth without interference with each other is evident. To satisfy the cargo handling problems, a two-story pier of this type for Philadelphia conditions should generally be 250 to 300 feet wide, preferably the latter, where apron tracks are installed.

As cargo operations should be handled on the pier within the length of the ship, the multiple berth pier should have a length equal to some multiple of a ship length. For instance, if the pier is intended to provide accommodations for two ships on a side, it should be 1,000 feet long if the unit ship length is assumed at 500 feet, and 1,200 feet long if the unit assumed is 600 feet. The latter, it might be stated, is preferable on account of the increasing size of cargo carrying vessels.

For present day ocean shipping, adequate dock or slip width is as important as wide pier construction. The docks must be wide enough to permit of bunkering ships while loading and discharging of cargo is in progress, and also for lighter service. It is by no means an uncommon practice to breast-off a ship from the wharf to allow coaling to be conducted between the ship and the pier while other loading operations are in progress on the "off side." A wide slip is necessary to avoid congestion.

To accommodate two modern freight ships, a dock width of 240 feet is desirable for efficient working conditions. Available bulkhead frontage will not always permit of the adoption of this width, but the absolute minimum should be fixed at 200 feet. For long piers, the width should be increased to 300 feet in order to provide proper bunkering and lighter service for the inshore berths without seriously interfering with the outshore ships. The 300-foot width of docks appears to be almost the adopted standard in planning modern facilities which incorporate long piers.

Any pier structure foundation should be designed to permit of dredging the docks, with safety, to a depth of 30 feet or more below low water.

More Than Half Billion Lamps in 1926

Well over a half billion incandescent lamps, including 315 million "large" lamps and about 205 million miniature lamps, were sold in the United States in 1926. These quantities represent the greatest annual increase in the history of the lamp industry during its almost half century of existence, says John Liston of the General Electric Company in his annual review of the electrical industry.

"It is estimated that, throughout the remainder of the world, the number of large lamps used is about equal to the quantity used in this country, and that the total of miniature lamps is about one-quarter the number used here, thus the present annual sale of all kinds of incandescent lamps throughout the world would aggregate about 900 million lamps."

Eighty Percent of Heat Wasted When Coal Is Not Turned Into Gas First

From eighty to ninety-five per cent of the energy stored in coal is lost when it is burned in furnaces or stoves. It is only the gas in the coal that is burned and much of the heat is lost, as well as all of the valuable by-products, when coal is burned in furnaces.

By modern gas-making methods each ton of coal will produce approximately 11,000 cubic feet of gas, 1400 pounds of coke, which contain as much heat as an equal amount of coal, five pounds of ammonia liquor, one and one-half gallons of benzol, ten gallons of tar, and a considerable amount of sulphur and naphthalene.

The gas can be burned with an efficiency of eighty per cent; the coke can be used as fuel or turned into additional gas by the carburetted water gas method; the sulphur, ammonia liquor and naphthalene can be converted into chemicals and fertilizer; and from the tar can be obtained dyes, perfumes and drugs.

Economics of Engineering in Port Development

By **M. A. LONG**

President, M. A. Long Co., Baltimore, Md.

AFTER working in the construction game for eight years, it is quite refreshing to me to again set my mind to thinking along engineering lines. During my twenty years in the Engineering Department of the Baltimore and Ohio Railroad, we had many problems on port development to solve and the results obtained were always highly interesting.

As in any other line of endeavor, efficiency and economy go hand in hand; the operation of our ports and the trade between nations is no different from other lines of trade in that they will follow along paths of least resistance, and Philadelphia, to be in a position to get its full share of this trade must plan her port accordingly.

It is necessary to have a proper design for every port, whether large or small, and it is also necessary that a study be made and the functions of the port properly co-ordinated for economical operation of the whole. Primarily they are designed for receipt of freight to and from land and ships, but of equal importance is the provision of facilities for warehousing and merchandising.

A complete port consists not only of channels, anchorages, quays, piers, warehouses and transit sheds, but also the necessary rail and road transportation facilities and space for storing and handling short and long time assembly of cargo and the storage of it in warehouses for repacking, manufacturing and reshipping by rail, steamship or truck to the eventual market.

American municipalities generally have allowed their ports to grow along the lines of least resistance. You can take two ports of equal importance commercially and you may find one with twice the wharf space of the other and in analyzing it you will find the underlying reasons therefor. It is usually found that the municipalities, the railroads and steamship lines are not working as a unit, but usually working against one another, or possibly two of the three working against the third. It is very important that the municipalities be the leaders in co-ordinating the facilities of the port so as to not only develop them to the maximum but develop them in such a way that they will be used to the maximum. It will be found that many wharfs and piers are not being used to capacity, due to the fact that the railroad owned piers are leased to one particular steamship line, which does not have enough sailings to operate them to their capacity. The same thing is true of some municipally owned piers and this method of operating does not earn proper interest on the investment.

For instance, when a steamship line owns the pier, it will seldom, if ever, provide space on it for railroad tracks. It may dictate to the railroads without expense to itself that the interchange shall be effected through the medium of trucking or floating equipment, and in either of these schemes there is the added cost of breaking bulk and rehandling.

In making the above statement, I have in mind the port of New York where they have piers that are older than the railroads, and on account of habit, no doubt, the older piers not having had railroad tracks either on the apron or the pier proper, refuse to become modern and add these facilities. No doubt these old installations fostered by the Steamship Companies were responsible for the Seaboard rate which requires the Railroad Company to interchange freight at the ship's side rather than at the end of the rail haul.

Practically all of the great ports of the Old World have had this in mind in developing their ports, but in our country where the ownership has been divided between the City or State, the Steamship Companies, Railroads, as well as private ownership, the differences of opinion are very marked.

Compared to the European ports, the American ports need to consider a more extended use of mechanical equipment for reducing the expense of handling the cargo as well as for expediting the release of ships and cars. Although labor in Europe is less than half the cost of labor in America, they use a great deal more mechanical equipment, and the interesting part is that most of it is made in America.

Recently a study has been made of a large port extension which shows that although the widening of the piers, including tracks thereon and with suitable track layouts to serve them, the addition of cranes, warehouses and driveways increased the construction cost approximately fifty per cent (50%), and reduced the space for berthing ships approximately ten percent (10%). This reduction in berthing space was more than made up in the increased speed of cargo handling as well as the release of ships and cars in a shorter time. .It also shows that, based on the nominal capacity, the efficiency of the port would be greatly increased and the terminal charges for ships as well as car demurrage and labor would be reduced at least thirty percent (30%) after making due allowance for the increased charge due to the increased first cost.

In making an estimate of this kind, it would not be directly applicable to every port, but it does, however, serve its purpose in directing attention to the necessity of a careful analysis of each port problem where rail and water carriers interchange freight.

You will therefore understand why records of American ports show an annual unloading capacity of from one-third to as little as one-tenth that of well planned and properly administered foreign harbors, calculated per foot of steamer berthing space.

Philadelphia is a typical American example. It has approximately 16,000 feet of deep water berthing space, publicly owned, 6,500 feet of additional deep water berths under private control and approximately 50,000 feet of additional berthing space suitable for coastwise and river purposes.

There is practically no warehouse space, as such, in the port that is municipally owned or controlled, and compared with foreign ports, there is relatively little under private ownership. The warehousing is done necessarily in the pier sheds where it was never intended, and should not be permitted.

Compare this with the port of Manchester, England, where about the same amount of foreign business is handled as in Philadelphia. They have only 34,000 lineal feet of berthing space and less than half of the deep water berthing that Philadelphia has, but on the other hand, warehousing accommodations amounting to approximately 3,500,000 square feet. In addition, the Manchester docks are equipped with mechanical handling equipment designed to facilitate cargo unloading and loading, developing every foot of storage to the maximum of cargo capacity. We find that in Canada, Montreal manages to handle an annual foreign tonnage of approximately the size and importance of Philadelphia deep water berthing accommodations, in eight months of open navigation—in other words—two-thirds of Philadelphia's working year. The case of Philadelphia is not unique, but merely typical of American practice.

A well planned terminal is the Bush Terminal in Brooklyn. This is a privately owned and managed terminal, and the last figures I have seen show a berth space of approximately 16,000 lineal feet, pier area of more than 1,000,000 square feet, and warehouse area in excess of 2,000,000 square feet. While engineers may not consider this terminal a model from a construction point of view, they must agree that it is almost an ideal layout from the standpoint of planning and the proportioning of its various facilities in their relation to each other and to the general scheme.

Habit is a great thing, but I would like to see one habit changed and a new feature of pier design used. Instead of building a two-story pier shed, build a ten or more story warehouse on top of the pier. Our river front property is about as expensive as any property in our cities except in the immediate business centre, and the warehouse in connection with the pier can be built for a great deal less than a warehouse built on a separate piece of land away from the pier. With modern methods of mechanical handling, the cost of warehousing would be very much less if the warehouse were constructed in connection with the pier. The terminal that in the future is built along these lines will find that its first cost as well as its operating cost will be materially reduced and it will be placed in a position to show much greater earnings than the terminals where the piers and warehouses are built separately.

There are some places where this scheme would not be practical, due to the uncertainty of the foundations, but they are very few, and it would cost very little more to provide a permanent foundation for a ten or twelve-story building, than it would to provide it for a terminal of two stories.

Where land is plentiful and cheap, it would be less expensive, of course, to build a quay rather than a pier, and in the last analysis, a quay is only half a pier insofar as operation is concerned, for to build it properly would cost just about as much as it would for half a pier, assuming that they were both built of the same quality of construction. Therefore, the only points at issue are, whether or not the business anticipated is such that it will require a full pier rather than half a one, and a forward look as to the probable value of the water front for the reasonable life of the quay.

If you were asked to decide for the owner what character of improvement you would recommend, you would have to consider a great many elements that have a bearing on the subject; for example, tidal change and other physical elements. The value of the water front as compared to the back land, density of business to be handled, etc.

It is interesting to note that in the United States the change of tide is not at all a determining factor, as the American type of pier may be found at terminals where we have a tidal change of one foot, as in Baltimore, and a tidal change of thirteen feet, as in Boston.

There is still room for improvement in the running of present terminals. The Interstate Commerce Commission should consider further restrictions in regard to storage, particularly in railroad cars, which is a wasteful burden on the rail carriers.

One of the most important items is the study of properly designed warehouses in connection with piers and railroad yards designed to properly handle and store commodities to reduce the cost of terminal handling charges, for it has been proven that it costs more per ton to load merchandise in cars at New York than it does to transport it from New York to Pittsburgh. I have never seen this applied to Philadelphia, but it is, in a measure, true here.

The reason for laying stress on this point is that competition in trade is going to grow from year to year. Europe is getting on her feet and will soon challenge us to meet its competition; we must, therefore, be in a position to handle foreign shipments as cheaply in our ports as they do in Europe. Trade between nations will follow along paths of least resistance and therefore pass through those gateways, other things being equal, that will exact the least tribute in toll, and in time, from the rail and water carriers which meet there for the purpose of interchange.

Impending Changes in Our Use of Fuels*

By ARTHUR D. LITTLE, Chem.D.
Vice-Chairman, Engineering Foundation Board

WHEN one observes a growing plant for an hour it seems a fixed and static thing. Such progressive change as may be taking place proceeds too slowly to make impression. When, however, the development, which may have taken months for its fulfillment, is crowded into the few minutes required to run off a motion-picture reel, we gain an altogether new appreciation of the dynamic power and driving force behind that evolution in which green shoots are followed by stem and branches, leaves, bursting buds, and flowers in full bloom.

It is much the same when we survey a specific industry. We may realize that changes are in progress, but the general impression we receive is one of established equilibrium. We need, therefore, to review quickly the development which has already taken place, in order that we may gain a true appreciation of the forces which urge it forward and that we may sense the direction of its trend.

Historical Review

Through the long course of centuries and down to times relatively very recent, wood was practically the only fuel used. Charcoal followed naturally as a derivative of wood. In the days of King Edward the First it was a capital offense to burn coal in London, and in 1306 a man was executed for the crime. The criminality slowly diminished in degree, but in 1550 Queen Elizabeth prohibited the burning of coal in London during the Parliamentary season for fear that "the health of the Knights of the Shire might suffer during their abode in the Metropolis." A little more than one hundred years ago it was as iniquitous, and perhaps more dangerous, to sell coal in Philadelphia than to sell liquor there today.

In 1804 the British Admiralty declared it their duty "to discourage the employment of steam vessels as . . . the introduction of steam vessels was calculated to strike a fatal blow to the naval supremacy of England."

In 1619 the growing scarcity of wood in England led Dudley to attempt the substitution of coal for charcoal in his blast furnace. The charcoal iron-masters drove him out of Worcester county. He set up another furnace at Hascobridge. A riot was organized and the furnace wrecked. In 1660 Dudley was still at work, undaunted, but unsuccessful.

Fortune dealt more generously with Abraham Darby, although with much deliberation. His use of coke in place of charcoal began about 1730, and in December, 1756, his furnace was declared to be "at the top pinnacle of prosperity, twenty to twenty-two tons a week and sold off as soon as made at profit enough."

At a time not later than 1688, and possibly somewhat earlier, the Rev. John Clayton heated coal in a retort and obtained gas and tar. He demonstrated that the gas could be burned and that it could be collected and stored. His results were duly published in a memoir, and forgotten.

The world moved slowly in those days. It was one hundred and fourteen years later that William Murdoch, in 1802, lighted his house at Redruth, Cornwall, with gas and developed the equipment upon which the gas industry was founded. It then waited thirty-five years for the gas producer and until 1874 for Lowe's first successful water-gas plant.

The first American gas company was organized in Baltimore in 1819, where today they consume more gas in five years than they did in the first century of their manufacture.

In 1840 practically no coal was mined in the United States. In 1860 our production was only a few million tons. In 1918 production reached a peak of about 740 million tons. It is now, under the competition of fuel oil and because of more efficient use, down to about 600 million tons.

In 1860 the annual per capita consumption of petroleum in the country was .016 barrel. We are now producing nearly 2½ million barrels a week and importing oil at that.

During the period from 1815 to 1914 the white population of the world increased about three-fold, but the production of mineral fuels—coal, oil, and natural gas—increased seventy-five-fold, and by far the largest proportion of this increase was in our own country.

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*Presented at the meeting of the Foundation at the University Club in New York, May 19, 1927.
Engineering Foundation, Publication No. 14.

The Increasing Demand for Energy

The pressure behind this amazing acceleration in our production and use of fuels is, of course. that insistent and constantly increasing demand for energy, which sharply differentiates modern civilization from those which have preceded it . Two pounds of coal will develop as much energy as a man at heavy labor for a day. The industrial status of a country is, therefore, largely determined by the supply of energy available to the individual worker, and nowhere is that supply comparable to that afforded him in the United States.

In 1770, except for a few small water powers, some wind mills and sailing vessels, and here and there in England a Newcomen engine for pumping water from the mines, the total power available to the world was that of human beings and draft animals. There were no railroads, no canals. The roads were bad, and the traveler was at the mercy of the highwayman. It cost as much to transport a ton of goods ten miles as it costs today to send it fifty times as far. Industry was cramped and necessarily localized; its markets were restricted and its rewards were meagre.

The work which maintains our present social structure is not, however, the work of the man with a hoe, it is the work of the farm tractor and the harvester; not that of the Chinese transport coolie, but of the locomotive engineer with a hundred loaded freight cars behind him; not the back-breaking effort of blowing a forge by hand, but the manual control of turbo-compressors forcing the fires of the blast furnace. It is, in short, work on the grand scale, which draws upon the material sources of energy to the utmost extent to which we are capable of utilizing them, while human energy supplies the controlling, regulating and steering agency.

Coal Our Chief Source of Energy

Since coal must remain for generations our chief energy resource, the line of progress parallels that which leads to the better utilization of coal. At the recent notable International Conference on Bituminous Coal, President Baker, of Carnegie Institute of Technology, said, "In less than a generation the present methods of shipping coal to be burned in its raw state under boilers hundreds of miles from the mines will appear to have been primitive and rudely unscientific."

That there is sound basis for President Baker's prophecy is evidenced by the fact that the problem of converting coal to products of higher form value is already the subject of extensive and costly experimentation in many countries, including, of course, our own. The general problem has many aspects and is being attacked from many angles.

The smoke screen, which enshrouds our cities, defiles our buildings, damages their contents, depresses our spirits, deprives us of the wholesome actinic rays of sunlight, and is a constant menace to health in other ways. Though general opinion is to the contrary, domestic heaters, including those of apartment houses, are responsible for the nuisance in larger measure than the furnaces of industrial plants. Our supply of anthracite is, relatively, very limited, and we have the authority of John Hays Hammond for the statement that in the anthracite mines the natural conditions are steadily getting harder. The average depth of workings has increased 77 per cent during the last generation, and the average thickness of the beds is barely half what it once was. The consequent high price of anthracite and the tendency of the miners to take a vacation as winter comes upon us have stimulated much earnest endeavor to find a substitute for anthracite through the conversion of soft coal to a smokeless fuel generally satisfactory to the householder.

Better Use of Coal

Foremost among these activities are the numerous processes for the so-called low-temperature carbonization of coal. Some two hundred of such processes have been listed, but it is doubtful if ten per cent of that number have been operated on anything approaching the commercial scale. Their distinguishing characteristic is that the coal is carbonized at temperatures rarely exceeding and often below 1100° Fahrenheit. As a result, there are obtained a moderate volume of gas of high heating power and valuable, in place of gas oil, for the enrichment of blue water gas, an excellent smokeless fuel in the form of semi-coke, and from twenty to forty gallons of a thin tar per ton of coal. This tar is markedly different from ordinary coal tar, and has, instead, much of the character of petroleum. It may be cracked to yield 22 per cent of motor fuel of high anti-knock quality.

Time and the limits of your patience permit only casual reference to a few representative processes. That of Professor S. W. Parr, of the University of Illinois, is the culmination of twenty-five years' study of the fundamental conditions involved in low-temperature carbonization. His process operates in two stages: a conditioning stage, in which the coal in a closed, rotating drum is quickly brought to within 25-50° of the temperature at which it becomes pasty, and a coking stage conducted in a vertical retort preheated to 750° C. Partly by reason of exothermic reactions within the coal the heat strikes to the center of the mass in 10-30 minutes, with production of a dense, strong semi-coke from cheap Illinois screenings.

The method developed by McIntire, at Fairmont, West Virginia, from the old Carbocoal process has a rather exceptional record of performance in that some 25,000 tons of coal have been processed. Its purpose is essentially that of making an artificial anthracite in the form of a briquetted smokeless fuel. It involves an initial low-temperature carbonization with mechanical stirring of the plastic mass of hot coal. This stage of the process yields from 2,000 pounds of coal 1480 pounds of semi-coke, 31 gallons of thin, light tar, and 2 gallons of light oil, together with about 3000 cubic feet of gas of 950 B.t.u. The semi-coke is then briquetted with a binder of by-product pitch and reheated, at higher temperature, with further yield of 2000 cubic feet of 450 B.t.u. gas and 8 gallons of heavy tar. The finished briquettes, containing 8-12 per cent of volatile, are dense and smokeless.

The Green-Laucks process of the Old Ben Coal Corporation, as installed at Waukegan, Illinois, passes a thin stream of coal upward by a screw within a vertical retort, 18 feet high and 3 feet in diameter, set in a furnace, the screw being heated through the shaft. The product of this pilot plant is said to be strong, dense, and smokeless. A commercial plant with retorts 9 feet in diameter is under construction, and if it functions well mechanically it would seem likely to do so commercially in view of the low initial value of the Illinois screenings used as raw material.

The product of the McEwen-Runge process, developed at the Lakeside plant of Milwaukee Electric Railway & Light Company, is intended for use in powdered coal equipment. It, again, is a two-stage process, in which the coal is first heated at medium temperature to destroy its coking property and then carbonized in a second retort. The two retorts, each 40 feet high and 6 feet 9 inches in diameter, are insulated, and one is superimposed on the other. Pulverized coal is fed into the upper retort, which discharges into a hopper, from which it is delivered to the second retort. The charge is heated by hot gases introduced into the retorts, each of which is provided with two combustion chambers. The gases enter at the bottom of the retorts and rise countercurrent to the descending coal. There is little loss of volatile material from the upper retort, and the gases are exhausted into the atmosphere. The gases from the second or carbonizing retort are removed to storage by a gas exhauster and amount to 3750 cubic feet of 850 B.t.u. gas per ton of coal.

Few details are available regarding the one-ton retort designed by Harold Stevens and operating at the plant of Detroit Edison Company, but it is stated that results have been so satisfactory that a 24-ton plant is about to be installed and operated in conjunction with the equipment of a small gas company.

In addition to these and other processes under development in this country, much serious work is being done on low-temperature carbonization in England and Germany, and it is claimed that one or two processes at least—the Coalite process in England and notably the K.S.G. process in Germany—are on a commercial basis. The latter is operating at Essen on a considerable scale, and a plant to handle 500 tons of raw coal a day is now under construction in South Wales.

The special type of retort developed for the K.S.G. process consists of a double revolving drum, the outer shell of which is 10 feet in diameter and 76 feet long. The inner shell is of the same length, but only 5 feet 8 inches in diameter. The retort is slightly inclined and surrounded by brick work. The coal is fed into the inner drum at its lower end and as the retort slowly revolves is gradually raised by cleats to the upper end, where it is delivered to the outer shell, within which it passes downward to the lower end and is there discharged as dense, hard lumps. The external retort is heated by producer gas, whereas the inner one receives only such heat as is transmitted through the coal in the outer drum. The coal in process thus receives a preliminary low-temperature treatment before being subjected to the higher temperature, which, together with the rotary motion, forms it into lumps of the character described.

Tests on American coals with 33-36 per cent volatile yielded semi-coke 1412 pounds; tar, 30.6 gallons; gas, 3470 cubic feet testing 772 B.t.u.,* and 3.3 gallons of motor spirit, per ton treated.

Coal Economics

The economics of the situation must, of course, finally control the development of any method of processing coal. The products must be worth more than the raw coal plus the cost of processing, though the energy content of the total products can never equal that of the original coal. We can look for profit only through the change in form value.

In England, where homes are heated by open grate fires, in which low-priced, raw bituminous coal is burned, the householder, who may protest against the smoke nuisance created by his neighbors, is slow to abate his own proportion of that nuisance if it involves paying more for semi-coke than he is charged for coal.

The problem of low-temperature carbonization in England is, therefore, the difficult one of operating at such low cost and of deriving such values from by-products that the semi-coke can be sold at substantially the price of the coal from which it is made, despite a shrinkage of 25 per cent or more in weight in passing from coal to smokeless fuel.

In our own country the situation is much more favorable, for the product of processing bituminous coal is intended to enter into competition with high-priced anthracite.

Progress and Opportunity

There is a widespread and growing interest in the low-temperature carbonization of coal and increasing activity in the development of methods. These are progressively improving as the reasons for earlier failures are recognized. It is doubtful, however, if there is yet in this country a process that can be said to have established definitely a successful commercial status. It seems, nevertheless, altogether probable that within a short time certain of the processes now in the developmental stage will take an assured and important place in fuel technology.

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*British thermal units.

Raw coal must continue to be for a long time to come the most economical fuel for large power stations except in situations that permit the tying together of low-temperature plants, gas works, and steam central stations, with delivery of semi-coke as boiler fuel and high B.t.u. gas for gas enrichment.

The broad opportunity for low-temperature carbonization is through the conversion of the immense available amount of cheap slack and screenings to high grade domestic fuel.

Beneficiation of New England Coals

The fuel problem in New England has been for years acute, despite the fact that there are great stores of coal in Massachusetts and Rhode Island. It is true that some people think it functions better as material for crucibles than on the grate, and the wise and lamented Professor Shaler did not advertise it favorably when he remarked that the safest place to be in at the conclusion of the Day of Judgment was a Rhode Island coal mine. Nevertheless, even the diamond will burn if you go about it properly, and so will these New England coals. They are very high in ash, but that ash can be reduced to 7 or 8 per cent. They are very low in volatile, but the volatile content can be raised. Both operations are in fact now going on.

We have all, from time to time, in recent years, heard much of the Trent process. You recall that in that process high-ash coal is subjected to wet grinding and thereafter agitated in a large volume of water, to which a moderate proportion of fuel oil has been added. The oil selectively wets the coal and gathers its particles into little balls not unlike caviar in appearance. The ash, for the most part, remains with the water and is washed away. The product of the de-ashing process is a putty-like amalgam containing about 8 per cent water, 16 per cent oil, and the balance as low-ash coal.

For various reasons this amalgam has failed to find acceptance as fuel for either domestic or power purposes. Quite recently, however, the process has been further extended, and the results obtained are of the most serious interest to New England and to the operators of anthracite mines.

In the process as now applied to Rhode Island coal and anthracite culm the amalgam is extruded and cut to briquette size. The briquettes are then baked under regulated temperature conditions, which permit the recovery of the major portion of the oil. The finished briquettes are equal, if not superior, to anthracite as a domestic fuel. They are of uniform size, dense, very hard, low in ash, and with about 8 per cent volatile. They ignite readily, burn freely without smoke, and hold the fire for a long period with maintenance of their shape.

The speed with which fuel developments are proceeding at this time and the dangers of prophecy are strikingly evident when these results are viewed in the light of the statement, made only last November, at the International Conference on Bituminous Coal, by so distinguished an authority as Marius R. Campbell.

In his paper on "Our Coal Supply" Mr. Campbell said regarding the super-anthracite fields of southern Massachusetts and Rhode Island:

"In this field, coal has been mined from time to time at Portsmouth and Providence, in Rhode Island, and at Mansfield, in Massachusetts, but none of the operations were long lived and it is doubtful if the material can ever be utilized as a fuel."

Liquid Fuels from Coal

Of less immediate practical importance in this country, though of greater interest in its far-reaching implications, is the process of Bergius for the conversion of coal to liquid fuels. In the plant at Manheim pulverized coal, made into a paste with oil, is heated to about 450 degrees Centigrade in an atmosphere of hydrogen under a pressure of 1800 pounds or more to the square inch. The coal is thereby largely converted into oil and tar, from which motor fuel, Diesel oils, lubricants, and heavy fuel oil are recovered. The crude yields and the character of the products are largely influenced by the nature of the coal used and vary from 93 to 140 gallons per ton of dry, ash-free coal.

As a measure of security in a country liable to have its supply of oil cut off in time of war the process is one of significant value. In the United States with crude oil selling for as low as $1.00 a barrel, it has the allurement of a long-term endowment policy. The possibility of its application to the treatment of heavy petroleum residues for the production of motor spirit and light oil suggests, however, an earlier development here.

Research and Tradition in the Gas Industry

J. E. Bullard has recently pointed out that "the real competition in which the gas industry is involved is that between research and tradition. The gas industry has followed tradition rather closely. Its competing industries have turned toward research and are willing to scrap all tradition." He continues, "Unless real research work is done and on a scale commensurate to that being done by competing industries, then the gas industry can take it for granted that it will have to relinquish more and more of its profitable business."

It is a timely warning, for the gas industry is entering upon a period of great expansion, in which the highest technical and scientific knowledge will be essential for the solution of the problems and the improvement of the opportunities which are before it.

The most significant of the developments immediately facing the industry are perhaps house heating and a greatly extended industrial use of gas. In case of both, gas offers the simplest and most reliable of the present systems of automatic heating. It can be burned at high efficiencies. The distribution of gas in underground mains is unaffected by weather or traffic conditions, and the service is among the most dependable of the utilities. Use of gas involves the consumer in no carrying charges. He pays for his fuel after it has been used. Under present conditions the householder pays more, but he receives more in comfort and convenience. In many industrial operations, however, the greater economy of gas is readily demonstrable.

The use of a gas flame to cool the refrigerator sounds paradoxical, but it may be recalled that wherever a motor-compressor unit is producing refrigeration a coal pile is somewhere being consumed to develop the electrical energy which drives the motor. Refrigeration by the direct use of gas thus eliminates a long chain of intermediate equipment. The required energy is furnished in much cheaper form; the apparatus involves neither motor, moving parts, nor lubrication. It makes small demand for service. Despite its present subordinate position in the art, the future of household refrigeration would seem to belong to the gas-fired unit.

Since gas has the highest form value of any type of fuel, a problem of outstanding importance to the gas industry is that of developing a thoroughly commercial method for the complete gasification of coal on the grand scale. The problem is apparently nearer to solution in England than with us. There some two hundred Tully plants are operating, but they are mostly of small capacity, making less than 500,000 cubic feet per day. In this process the coal is first carbonized in a vertical retort, set over a water-gas generator, into which the coke descends. The retort is heated externally by the blow gas and internally heated by the water gas generated during the "up runs." The yield of mixed or double gas per ton of coal varies from 40,000 to 53,000 cubic feet of 350 B.t.u.

Among those methods of complete gasification, which have come into less general use, mention should be made of the Kreisa system operating in Germany and Austria. It somewhat resembles the Tully process, but yields a gas of 450 B.t.u., provides for the continuous removal of ash, and, in place of a boiler for generating steam, utilizes a metal checker-work, which, heated by the gases of the blow period, and thereafter sprayed with water, provides, in balanced proportion, the steam required for the run.

In 1925 there were sold in the United States 422 trillion cubic feet of manufactured gas, whereas only 112 trillion, if one can apply the word "only" to figures of such astronomical dimensions, were sold in 1905, an increase of 376 per cent in twenty years. With the industry facing a five-fold further increase in the next decade or two, factors similar to those which have determined the integration of the production and distribution of electricity may be expected to bring about a like development in the manufacture and distribution of gas.

Our smaller municipal gas companies are too often antiquated organizations, without vision, and far from realizing, either in their present practice, or in their preparation for the future, the possibilities of the industry. In many cases their communities could be more effectively and cheaply served through high-pressure transmission lines from large central gas plants. Natural gas is now piped 300 miles, and a projected line from the Texas Panhandle to Kansas City will be 450 miles in length. It is designed to deliver 36½ billion cubic feet a year at a maximum pressure of 450 pounds.

In the Chicago district, along the Atlantic seaboard, and at a few points elsewhere, there exist great markets for manufactured gas within much shorter distances from the mines. There are few locations where adequate condensing water for super-power plants is available at the mine, but super-gas works are not subject to this limitation.

Gas Developments Abroad

We shall do well, therefore, to watch the development of projects now under serious consideration in Germany for concentrating in the Ruhr the entire gas industry of the country and effecting distribution through high-pressure lines. We may find much food for thought in the following statement of the ambitious program of the Coal Utilization Company of Essen:

"Contrary to press statements that the new company is not concerned with the chemistry of coal, I must say here that its field is unlimited. It will use mechanical, electrical and chemical methods to arrive at its object. All processes which use water, air and coal as raw materials belong to the activities of this company. Coal which is otherwise unsalable must be changed to other forms of energy, or to other materials, for which there is a market. It is natural that the new company cannot begin at once all the methods of work. Its activities will be divided into those which can be immediately applied and those which must be left for the future. In the first class belong the distant supply of gas, district heating, the application of coal distillation, gasification and firing of powdered coal. For the future there are those modern chemical processes which have coal for their raw material but which require further scientific study and which before technical application is possible must be submitted to extensive investigation."

The modern chemical processes referred to are presumably those which Bergius, Fischer, and Patart described at the Pittsburgh Coal Conference. Mention has already been made of the first of these. That of Fischer produces gaseous, liquid, and solid hydrocarbons from water gas, while Patart disclosed a method of making acids, alcohols, and numerous other series of important organic compounds from the same product of the gas works.

Coke-oven gas is already being distributed over a radius of 62.5 miles from the Ruhr. They believe that the problem of leakage over much longer lines under higher pressure "is entirely solved by processes for welding the gas lines."

In the Rhine-Westphalia coal district it is proposed to build a gas-collecting system which will extend from Hamborn to Hamm, into which the several coke-oven plants will pump their gas. This pipe line will follow the water courses through the coal district. The purification of the gas will be made at the end of the collecting system, where there will be located the gas holders and compressing station. Four sections of the main pipe lines have been projected from the Ruhr district:

1. Through Bremen and Hamburg to Lubeck and Kiel.
2. Through Hanover and Magdeburg to Berlin and Stettin.
3. Through Kassel and Thüringen to Saxony and later through Lower and Upper Silesia and the Saxon mining district.
4. A line following the Rhine to Hesse, Baden, Wurtemberg, and Bavaria.

It is claimed that the transmission of gas in great volume by pipe line is much less than the transport of coal by rail to local gas works, and in view of other savings it is planned to have one basic price for gas for the whole country. The distant gas transmission will, it is believed, be subject to the same economic laws as high-tension electric transmission. It would be intermingled with and unite the communal and private concerns, local distribution and long-distance transmission.

In connection with this general plan much importance is attached to the possibility of utilizing cheap oxygen in water-gas sets, which would thereby operate continuously with a mixture of oxygen and steam. Our own studies indicate that such a generator might easily use 25 per cent less fuel for a given output and have twice the capacity for a given size. Such operation would permit the use of a solid hearth with slag removed in liquid form, thereby saving grate troubles and clinkering and making available low grades of coal with a low fusing ash.

Research a Corrective for Waste

After generations of reckless waste in our utilization of the fuel resources of our country we are beginning vaguely to recognize the urge of that hoarding instinct which, it has been said, marks the dawning of economic consciousness in the progress of civilization. We have only to contemplate the situation into which opportunist development has brought us, as regards our coal, our oil, our natural gas, and our forests, to realize that most of the wastes, delays, and difficulties which characterize that situation are due simply to lack of planning years in advance, and to our failure to embody in some coördinated general plan those lines of action which are well recognized by experts as essential to our proper development as an industrial nation.

No agency is better qualified to assist effectively in the development of such a plan or in the organization of those lines of research which must accompany this development than The Engineering Foundation, through which may be focused the integrated experience of our great national engineering societies.

Higher Endeavor in Science*

Extracts from an Address of

DR. MICHAEL I. PUPIN

Professor of Electro-Mechanics of Columbia University

PHILADELPHIA, Princeton, and Menlo Park are the beginning, the middle, and the end of a tiny bit of territory which is the cradle of American history. The scientific achievements of Franklin, of Joseph Henry, and of Edison laid the foundation and added some of the superstructures of earlier American science.

Prior to Franklin's time the natural philosopher riveted his attention upon electricity at rest. Franklin's discovery that lightning is a motion of electricity revolutionized the mental attitude of the natural philosopher of Franklin's time, and motion of electricity became the favorite subject of his inquiry. Just as during the century preceding Franklin the genius of Galileo and of Newton had revealed a new universe, the universe of matter moving in obedience to simple laws, so during the century which Franklin's discovery inaugurated a new universe was revealed; it is the universe of electricity in motion obeying simple laws of electrical action. The discovery and formulation of these laws are the greatest scientific glory of the century which began with Franklin's discovery.

Joseph Henry's discovery of the inertia of electricity is one of the greatest contributions to the glory of this remarkable century. His great electro-magnet which gave birth to this discovery is still here in Princeton. Grateful science, recognizing the eminent value of this work, named the unit of electromagnetic inertia after Henry, and thus assigned to him a place of honor in the Hall of Fame of Science. In this Hall of Fame is the Valhalla where Joseph Henry and other immortals like Volta, Ohm, Ampere, and Faraday dwell. Just think of it! Princeton, a little village in a little state, represented by Henry among the immortals in the Valhalla of Science. Think of it, and it will recall to your mind another glorious picture, the picture of little Cambridge represented by Newton in the same Valhalla of Science.

It is not as generally known as it ought to be that Joseph Henry is the inventor of the electromagnetic telegraph which he, nearly a hundred years ago, operated between his house and his laboratory at Princeton. This was the beginning of the present art of electrical communication which enables us today to speak at any time to any person in the United States. Would that Washington and Lincoln could have forseen this new power for the consolidation of the American Union!

Henry knew the practical value of his invention, but that did not divert him from the pursuit of a new truth the vision of which appeared to him in the activities of moving electricity. He let the practical men like Wheatstone and Morse develop the practical applications of his electro-magnetic experiments; he worshipped at the temple dedicated to the eternal truth of science, and there he found the revelation of the inertia of moving electricity, a new glimpse of the eternal truth never caught before by the eye of man.

No elaborate statistical figures are needed to demonstrate the value of higher endeavors in science. Every industry in the land recognized this value long ago. The practical value of the eternal truth is known today to the practical man just as its spiritual value was known to the prophets of several thousand years ago. The same eternal truth which, according to the prophets promises spiritual freedom, promises today economic freedom. American industries are craving today for the revelation of scientific truth, and the only problem which faces us today is the problem of the training of our generation in the science and in the art of revealing new scientific truth. Pure science research and the engineering discipline which will apply efficiently the findings of pure science to the development of our industries and of our daily life is now our national motto; it is the motto of our universities as well as of our industries.

Scientific research laboratories are springing up on every side in our American industries; they are by universal consent the most effective arms of our national defense. They call for trained men capable of searching for the primordial energies hidden in the mysterious structure of matter. He who has a new glimpse of the eternal truth can unlock these hidden energies and make them willing servants of man, the most powerful defenders of his freedom.

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*On the occasion of the laying of the corner-stones of the Princeton Chemical Laboratory and Princeton Engineering Building, May 12, 1927.

Strengthening Highway and City Street Foundations to Meet the Increase in Motor Bus and Truck Traffic

Editor's Note.—The final record of the Conference on the above subject, the last portion of which appeared in our May issue, will be printed in our July issue. It should have appeared in this issue, but has been unavoidably delayed.

Items of Interest

A New Course in Fuel Engineering

A move in the right direction and one which will result in very great and lasting benefits to all users of fuel, has been inaugurated by the Department of Mechanical Engineering, University of Pennsylvania, under the direction of Dr. Robert H. Fernald, Director of that Department.

This course is announced to begin September 30, 1927. Details of the course of instruction offered, list of lecturers who will present various phases of the subject, the schedule of subjects offered, and fees charged, may be obtained in pamphlet form from the Dean, Towne Scientific School, University of Pennsylvania.

The course is inaugurated for rounding out the broad training of an engineer along lines necessary to group him as a specialist in Fuel Engineering. It is designed primarily for College graduates. Special students not necessarily graduates, however, will be admitted as "auditors" for any of the lectures upon payment of designated fees.

Dr. Fernald has been especially fortunate in arranging with many men who are outstanding authorities in various phases of the general subject, "Fuel." Many of these lecturers are at present actively engaged in, and devoting their entire attention to, the production or the economic use of fuel.

The list of subjects in this course of study is as follows:

Fuel Resources.
Mining Methods: Preparation for Market; Distribution; Storage and Re-handling.
Composition and Combustion of Fuels.
Manufacture of Special Fuels.
Uses of Fuels and Specifications for Purchase.
Furnaces.
Fuel Sampling, Analysis and Calorimetry.
Fuel Testing in Heating and Power Appliances.
Domestic Heating; Cooking; Smoke Elimination.
Regulations Affecting Use of Water Power and of Fuel Resources.
Research.

Building Roads to Suit Vehicles

For a long time highway officials insisted that motor vehicles should be adapted to the highways but now highway departments are trying to adapt the highways to the vehicles and the traffic, asserted Prof. T. R. Agg, of the highway engineering division at Iowa State College and chairman of a committee of the Highway Research Board of the National Research Council, at a recent meeting of the Metropolitan Section of the Society of Automotive Engineers in New York. Limitation of loads and of sizes of vehicle must necessarily continue as a safeguard to the existing investment in highways, but regulations in this regard are made as liberal as conditions allow.

The new conception of the function of highway systems has made it imperative that highway engineers obtain a clear understanding of the inter-relation of the highway and the vehicle, that is, the reciprocal effect of the road and the vehicle upon each other.

Low and intermediate types of road surface wear tires from four to ten times faster than high-type road surfaces, and surfaces of loose angular stone may produce twenty times the wear on the tires caused by high-type surfaces. The most economical road grade, as a general principle, said Professor Agg, is one that will allow a vehicle to ascend in high gear at the most efficient engine speed and to descend without the use of brakes and without attaining excessive speed.

The best type of car road for heavy traffic is a concrete road 12 inches thick that has about 40 pounds of steel re-enforcement in each square and with the slabs laid in lanes about 10 feet wide so articulated that more lanes can be added if needed and with expansion joints every 35 feet. On heavily traveled roads each foot of distance saved will justify an expenditure of at least $60 and this should be borne in mind when the shortening of distance entails heavy grading or other expense. When a road grade requires the shifting of gears and excessive use of the brakes, extra cost for gasoline and tire wear will result and can be estimated. This extra cost, however, may be less than that of traveling the extra distance required to secure a lower rate of grade.

The cost of any type of road is the aggregate of the expenditures required to build the surface and to keep it in a condition of maximum serviceability over an indefinite period of years.

American Philosophical Society

The Bicentenary Celebration of the founding of the American Philosophical Society by Benjamin Franklin was held April 28th to the 30th, 1927, at the rooms of the Society in Philadelphia.

The program opened with somewhat formal presentation of the delegates to the President of the American Philosophical Society, after which the President gave an address upon the "Dynamic Factor in Evolution." In commenting on this paper some of the newspapers gave the impression that it was somewhat materialistic and seemed to exclude any divine plan as a factor in evolution. The impression upon my mind was not that it excluded a divine origin of the universe, but perhaps it seemed inclined toward the idea that evolution proceeded under the influence of energy inherent in protoplasmic units and was affected by environment but did not travel along any preconceived route. In other words that the pathway of evolution was not subject to the doctrine of pre-destination any more than most of our religious sects.

The address of Dr. Charles E. Sajous, of Philadelphia, upon "The Endrocrine Organs," their functions and relation to the science of medicine was striking and gave great hope for important advances in the prevention and cure of some of our most fatal diseases.

The address of Dr. Charles G. Abbott, Director, Astro-Physical Observatory, Smithsonian Institution, upon the "Accomplishments of Modern Astronomy" contained among other things most interesting and impressive figures bearing upon the probable limits of our universe, the number and size of the stars and the probabilities of existence on some other planets of our own universe.

Among the most brilliant papers was that by Professor Robert A. Millikan, the great Physicist of California Institute of Technology upon "Recent Developments in Spectroscopy." It was chiefly concerned with the matter of atomic structure and he developed the thesis which appeared to be supported by some recent spectroscopic and previous physical experiments that the electrons not only rotated about the nucleus in closed curves similar to the paths pursued by celestial bodies, but that these orbits were in different planes and that the electrons in addition revolved around their own axes. In other words the fundamental elementary bodies of these infinitesimally minute atomic systems were possessed of the same kinds of motions as are found in our immense celestial systems.

The paper by Professor W. A. Noyes, of the University of Illinois, on "Valence" treated the constitution of the atom from the chemical standpoint and among other things showed how the Valence, or as we were more accustomed to call it some years ago "quanti-valence," could be illustrated and explained by the electronic theory of atomic construction. That different investigators proceeding on the one hand along physical, and on the other hand along chemical pathways, should arrive at similar and substantiating conclusions certainly gives an extremely strong probability to the correctness of our present ideas of the constitution of the atom.

The paper of a former Philadelphian, Dr. Herbert E. Ives, upon "Photoelectric Photo-engraving" indicated some of the experimental work which was concerned with the recent achievements in Television.

The lecture at the Historical Society Hall by Henry F. Osborn, President of the American Museum of Natural History, upon "Recent Discoveries relating to the Origin and Antiquity of Man" was particularly interesting in that it correlated into a definite chronology the several discoveries of pre-historic skulls and bones and that it pushed much farther back the beginnings of man. Professor Osborn asserted without question that the beginning of man was at least one and a quarter million years ago. He further gave the assurance that must have been comforting to those interested in genealogy that if man and the monkey did both descend from the common primal stem that the split-off was at least that many years ago.

An outstanding address, not upon the program, was that of Dr. W. W. Keen, a former President of the American Philosophical Society, and now ninety-one years young. Dr. Keen spoke upon the need and prospects for a new building for the Society to cost some two million dollars. He mentioned some of the priceless historical documents and relics in the hands of the Society, one of them being an original draft of the Declaration of Independence by Thomas Jefferson, who by the way was also a former President of the Society.

C. W. P.

Flood Control Plans Should Include Reforestation and Control of Soil Erosion

The greatest flood disaster this country has ever known is bringing a realization of the need for a well established policy of flood prevention, says the United States Department of Agriculture in calling attention to two important factors in the control of the rapid run-off of water—reforestation and the reduction of soil erosion. The importance of forests in this respect has long been emphasized, but until recently very little attention has been given to the effect of the continued destructive washing of large areas of cultivated farm land and pasture lands.

"Failure to hold the absorptive surface soil of fields and pastures against the denudation of erosion," says H. H. Bennett, of the Bureau of Soils, "has contributed to a much more rapid removal of the water that falls upon these eroded lands. The mellow top soil that is gone was far more retentive of moisture than the comparatively impervious subsoil that sheet erosion has left behind." Extensive reforestation in the long run by retarding the run-off, will supplement the artificial engineering work. Every dollar expended in reforesting denuded land will return with interest through the sale of forest products and water power and stimulation of industry. Flood prevention will come as a by-product without actual cost.

The particular flood prevention recommendations of the Department of Agriculture may be summed up briefly as follows: The general reduction of soil erosion to prevent rapid run-off and the clogging of streams; largely increased efforts by the States and Federal Government and private owners for co-operative forest fire control; largely increased programs for public forests on tributary headwaters both by the Federal and State Governments; a much larger program of tree planting on denuded forest lands; encouragement of farmers and other land owners, through State and Federal aid, to plant trees on rough lands and along water courses: and a study of the possibilities of restoring some of the bottom lands to their original condition as carriers of flood waters and producers of forests and game.

The Business Situation

Editor's Note.—The following review of Business Situation is from the June Bulletin, Colonel Leonard P. Ayers, Editor, issued by the Cleveland Trust Co.

THE summer months of June, July and August are normally a time when general business slows down somewhat, and apparently the present summer season will be no exception to the rule. Nevertheless it does not seem likely that such slowing down of trade and industry as may take place will be greater than that which is to be expected because of purely seasonal reasons. Commerce and manufacturing are going forward in exceptionally steady fashion, and they promise to continue in about the same way in the months just ahead. The agricultural situation is spotty, with flood troubles of the most serious sort in the south, and exceptional backwardness in some other parts of the country, but it is yet too early to make many generalizations about the agricultural prospects.

The steady and ample supply of credit available on easy terms has been perhaps the most important single factor in making possible the present protracted period of national prosperity. This condition will probably continue for some time to come. During the past two years the rates for the highest grades of commercial paper and time loans have fluctuated a little above and a little below the four and a half per cent level. It now seems likely that they will continue to do so during the rest of 1927 with a normal seasonal advance getting under way in July, and resulting in the average of short time interest rates being higher for the second half of this year than for the first half. There is no likelihood that such an advance will be of enough magnitude to exercise any restraining effect on the ordinary transactions of business, although it might well result in bringing about a decline in an overbought stock market next fall.

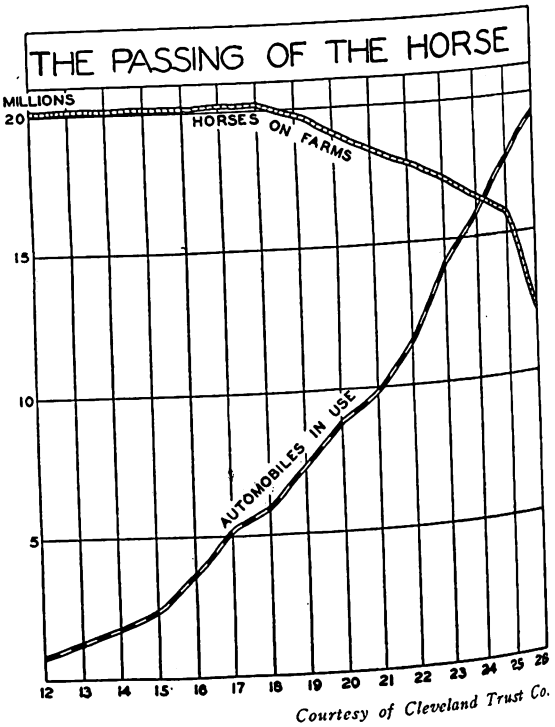
Building construction continues to go forward in almost record volume, and the work now in progress, together with contracts placed or pending, are a sufficient guarantee that this most important industry will continue to be a supporting force in general business activity during the rest of the year. In the automobile industry, activity which has been so great so far this year, is now slackening off as the different companies reduce their production schedules because the press of the spring demand has passed, or to prepare for the making of new models for presentation to the public during the summer. The really stirring developments for the industry this year may be expected later on after the appearance of the new Ford cars.

All in all the current developments of business continue to be those of large volumes of production, transportation, and trade, stability of conditions, and keenness of competition. There is little unemployment, but no competition for labor. Wages are high and wage disputes few. The railroads continue to carry great amounts of freight, and to do it with marked efficiency. It seems likely that substantially these same conditions will maintain for some months to come.

Horses and Motors

Every little while some newspaper republishes the old and erroneous information that despite the increased use of passenger automobiles and motor trucks there are today as many horses in use in this country as there ever were. This bit of misinformation has a companion piece which also appears in print every little while giving the equally untrue information that as many bicycles are annually made and sold in this country as there were 25 or 30 years ago.

The department of Agriculture has recently published figures showing the number of horses on farms in this country each year for a number of years past, and the data completely fail to uphold the popular newspaper story. In the diagram the upper line shows the number of millions of horses on farms each year since 1912. At that time there were about 20 millions of them, and that number remained almost unchanged until after the end of the war in 1918. It then began to decline, and the reduction has continued with increasing velocity, until last year it was well along toward being cut in half. If the fig-



Courtesy of Cleveland Trust Co.

ures for the horse census included those in the towns and cities the reduction would presumably be still more marked.

The lower line shows for the same span of years the rapidly increasing number of passenger cars and motor trucks in use. It is clear that even the farm horse is being displaced in ever increasing numbers by the motor vehicles. The economic implications of the transition are important. As the motor displaces the horse thousands of acres of land used for raising hay and oats are released for other crops; the amount of human labor needed on farms tends to be reduced; and the need of the farmers for greater money incomes is increased.

Iron and Steel

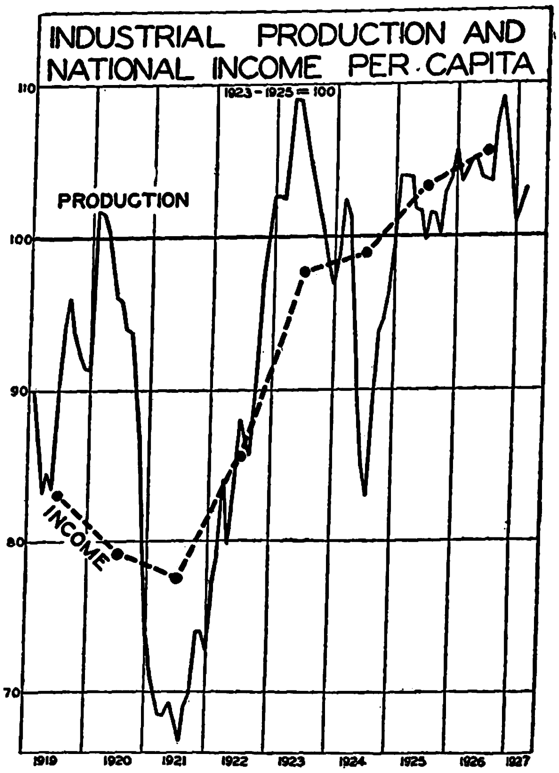
The production of steel in the first five months of 1927 has reached almost exactly the volume of output in the corresponding five months of 1926. The takings of the railroads and the automobile companies, which are the large tonnage buyers, have been about 10 per cent smaller than they were last year, so that it has remained for the construction industry and miscellaneous manufacturing to make up the difference.

The steel companies have been obliged to put forth exceptionally vigorous efforts to round up the aggregate of numerous small orders that has made up for the deficient purchasing of the large consumers, and this has resulted in such keen competition that prices have generally declined. Quotations on some classes of steel products are now lower than they have been before during the past five years. The general sentiment among the steel companies is that there is nothing the matter with the volume of business, but that the industry is passing through a period of profitless prosperity.

On May 31, the percentage of active blast furnaces dropped below the 60 per cent line. On that date 211 furnaces, or 58.1 per cent, were in blast compared with 221, or 60.7 per cent on April 30, and 223, or 61.1 per cent at the end of March. Last May 229 blast furnaces, or 60.9 per cent, were on the active list, but increased efficiency and the trend toward larger units account for the fact that pig iron production this May almost equalled that of last May although 18 fewer units were operating.

Production and Income

Industrial production in this country fluctuates far more widely than does national income, but nevertheless there has been a close general relationship between them during the years since the war. This is well illustrated in the diagram which covers the years from 1919 up to the present time.



Courtesy of Cleveland Trust Co.

The irregular solid line represents the monthly fluctuations in the physical volume of industrial production as computed by the Federal Reserve Board. The average for the three years from 1923 through 1925 is taken as being equal to 100. The line well reflects the great depression of 1921, the brief prosperity of 1923, the minor period of slow activity in 1924, and the high levels of industrial output in 1925, 1926, and the first quarter of 1927.

The dashed line shows the course of national income as computed by the National Bureau of Economic Research, and in this case also the average for the years 1923, 1924, and 1925 is taken as equal to 100, and the data for the different years are reduced to relative amounts that are less than 100, or in excess of it. The general agreement in the trends of the two lines is apparent in the diagram.

It has long been recognized that there is in this country a close relationship between national prosperity and industrial activity, and this has been reflected in the widely accepted use of industrial figures such as those showing the amounts of new building going on, or the volume of iron and steel output, as indicators of the changes in general business.

It is probable that changes in industrial production now bear a closer relationship to variations in national income than they did in former years when agriculture was a relatively more important source of the production of wealth than it is now. Unfortunately the comparison shown in the diagram cannot be carried back further because the production index of the Federal Reserve Board has been computed only for the years since the beginning of 1919.

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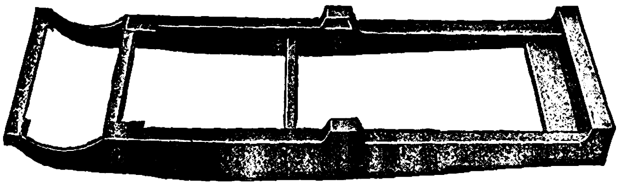
(Continued next page)

Note The Frame Construction.



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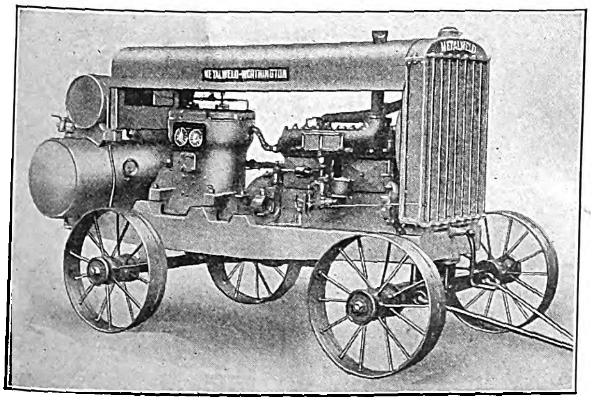

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ENGINEERS & ENGINEERING

JULY, 1927

FOUNDED 1879

Vol. XLIV No. 7

CORRECTION:

June issue, Page 150, right-hand column, 33rd line from top change figures "30" to 38 to make line read *depth of 38 feet or more below low water.*

Recent Developments in Highway Research

By PROFESSOR S. S. STEINBERG

University of Maryland.

Assistant Director, Highway Research Board, National Research Ccuncil

OF the many problems confronting the highway engineer, the most important, the most complex and the one in which the public is most vitally interested, is that of highway safety. The loss of some 25,000 lives annually, the injury of several times that number and the enormous property damage, have focused the attention of many agencies upon this grave problem of national concern. Highway safety, though primarily an engineering problem, is considerably influenced by the psychological as well as the physical demands upon the driver of a motor vehicle.

A recent statistical study of the distribution of blame among factors involved in highway accidents, has shown that the "human factor" is responsible for approximately 90 per cent of motor vehicle accidents, and that causes attributed directly to defects in the highway or the vehicle are of small relative importance.

Skidding of tires on wet pavements, which is a frequent cause of accidents, has been investigated at Iowa State College. These experiments, using pneumatic tires on various road surface conditions, show that on roads coated with snow or ice or with oily slime or mud, the force required to cause skidding is approximately one-third to one-fourth of that on clean, dry surfaces; while on icy roads that are thawing a little, the coefficient may be as low as one-sixth that on a clean dry surface.

A number of problems, especially those affecting motor vehicle operation, are being studied by the United States Bureau of Standards. One of the most important of these is safe and adequate braking control of vehicles. A simple and convenient indicating accelerometer has been designed with which the braking ability of several hundred typical motor vehicles of all classes, selected at random from traffic, has been measured. About a thousand such instruments are now in use throughout the country in order to make a more extended study of conditions in regard to this important phase of motor vehicle operation.

Automotive headlighting and its relation to highway illumination has also been a subject of recent study. The Bureau of Standards in co-operation with interested organizations has been making a study of the safety and effectiveness of different head-light illumination patterns. Work is under way to determine what type of lighting is safest for the driver when no other cars are approaching and what type is best for both when cars are approaching.

Interesting results have been obtained from investigations on tire wear, tractive resistance of road surfaces and wind resistance on automobiles, each of which is an important economic factor in highway operation. One of the problems that confronts all of us is the life efficiency of tires. Experiments on tires conducted at the State College of Washington show that tire wear increases with the speed of the vehicle and with increase in temperature. Rear tires are found to wear 50 per cent more than front tires. The experiments indicate that under normal conditions of vehicle load and tire inflation, the relative wear of tires on different kinds of roads represent useful mileages of 24,000 on the best road surface to as low as 2,000 on the worst. Considering that the average vehicle travels 6,000 miles per year, the annual tire cost per car varies from $30 to more than $300, depending upon the kind of road surface the vehicle uses.

Research conducted at the North Carolina State College on the power required to drive motor vehicles on different road surfaces, showed that at fifteen miles an hour twice the horsepower is needed to propel a vehicle on a wet and muddy surface as on a dry and smooth one. Studies on the effect of speed showed that almost four times as much power is required to run the vehicle at thirty miles an hour as at fifteen miles an hour.

An investigation on the effect of the wind upon a car traveling at various speeds was conducted at the Iowa State College and the results confirm those previously obtained at the Kansas State Agricultural College. In these experiments it was shown that when you drive your car at thirty-five miles an hour you use, on the average, eight horsepower to overcome wind resistance. If you reduce your speed to twenty-five miles an hour, you save five horsepower.

As a result of another comprehensive investigation recently completed by the Bureau of Public Roads, it has been demonstrated that paving brick 2½ inches in thickness is satisfactory for heavy traffic and that 2-inch brick is adequate for light traffic. As these sizes replace brick of four inches and three inches formerly used, it is evident that the application of this single research will mean immense savings annually in road construction.

One of the important highway research problems recently undertaken is that of scientific study of the soil underlying the road. Highway engineers have been severely handicapped by the absence of information regarding the various types of road soils and their behavior under all weather and traffic conditions. Due to lack of such knowledge pavements cannot be designed to fit subgrade conditions, with the result that roads often break down from causes not now fully understood. The federal government, as well as a number of the states, have embarked on extensive soil surveys with the object of developing standard methods for identifying and testing road soils and determining methods for improving their quality to make them fit for use as road foundations.

Strengthening Highway and City Street Foundations to Meet the Increase in Motor-Bus and Truck Traffic

(Continued from May issue, page 130)

DISCUSSION

MR. ADLER: Mr. Chairman, there were two points in Mr. Tebbs' discussion that if I understood them correctly, were a little bit difficult to reconcile. In his opening remarks, he said that his Department recognized the difference in the behavior of concrete laid under rural conditions with open, undrained shoulders adjacent to the roadway, and concrete laid under typical city conditions with curbing adjacent to the edges, with the greatly reduced likelihood of the sub-grade near the edges becoming saturated. Then, as I understand it, Mr. Tebbs develops the theory for the necessary thickness of a concrete roadway where the shoulders are open and unwaterproofed, and then applied that thickness afterwards to the case of a foundation with a 1-2½-5 mixture, arriving at the conclusion that for wheel loads of 9750 pounds it would require an approximate thickness of nine inches of concrete at the edge, and .7 of that thickness at the center. Apparently, that doesn't take into account the opening admonition that if you have a curb and sidewalk, or in other words if you have protection from saturation of the sub-grade near the edges, that the same provision for additional thickness, or for thickness in the edges, may not be required. Did I understand your general theory, Mr. Tebbs?

MR. TEBBS: The effect of the moisture in the sub-grade is very difficult. I said that I was developing a design for base course equivalent to our reinforced concrete pavement in strength. A base course developed to be the equivalent of our heavier type of reinforced concrete pavement would require the depths that I referred to. I stated also that in cases of uniform depth, we used a uniform depth ½" greater in thickness than the designed center thickness, provided that there will be no free or undoweled construction joints in the pavement.

MR. ADLER: Does that apply if you were using concrete foundation under some form of surfacing, which I believe you do to some extent, do you then use the thickened edge?

MR. TEBBS: Yes, excepting where we have a wide pavement between curbs where we use a depth ½" greater than the computed center thickness and have no free edges in pavement. Along the outer edge adjacent to the curb we consider that there will be but little traffic, that it will be mainly used for parking. If we find there is going to be a considerable amount of heavy traffic adjacent to the curb, then we thicken the edge.

MR. ADLER: Are you taking into consideration the additional strength which might vary considerably with the type of surfacing? For example, we have discussed granite block, vitrified block, asphalt, etc., and aside from questions of impact which Mr. Jackson has discussed, your design for thickened edge is not one which is based on impact load, but is a static loading design.

MR. TEBBS: This is a design for static loading with a factor of safety to take care of the impact.

MR. ADLER: I stand corrected. But then isn't it true that with any type of surfacing whatever on top of your concrete foundation, that the bending movement, about a point seventeen inches in, or two feet parallel to the edge of the roadway, would be somewhat reduced as a result of the increased thickness resulting from the surfacing of the roadway?

MR. TEBBS: We do not find considerable reduction of impact by the surfacing.

MR. ROSENGARTEN: What is the practice in Pennsylvania in regard to expansion or contraction joints for the pavement and also the bases?

MR. TEBBS: We use no expansion joints in bases. We use them at intervals of approximately 200 feet in reinforced concrete.

MR. SKILTON: May I ask Mr. Tebbs why he advocates the use of a plate on the center joint instead of the use of some bituminous premoulded joint?

MR. TEBBS: The elastic material in the joint would defeat our purpose. We want to hold the slabs close together.

MR. SKILTON: Will they have the motion if you have the dowels in there?

MR. TEBBS: We think that the slabs should be held in absolute contact, so that the concrete dovetail as well as the dowels will act in shear.

MR. SKILTON: I would like to ask a further question, Mr. Tebbs. Of course, this theory of design of thickened edge is based on static load, etc. I understand that up to recent years, concrete pavements were built to a great extent through the country with uniform thickness throughout. Take a half mile or a mile of granite on any pavement of that sort; how many corners would you see broken off?

MR. TEBBS: I cannot answer your direct question. At first we built pavements eight inches thick in the center and six inches thick on the edges, and where there has been heavy traffic, the constant use of the outer edges has resulted in a considerable amount of corner breaking. There is an example on the West Chester Pike, at 69th Street Terminal, near Garrett Road. It is an accelerated test, you might say, of that type of design. It is the thickness of the edge and not the depth of the remainder of the pavement that governs corner breaking.

MR. JACKSON: Have you ever noticed any evidence of excessive transverse cracking due to carrying your steel in bond of long distances, such as 200 or 250 feet?

MR. TEBBS: In 1923 the ⅝″ edge bars were lapped eight inches, and we had some trouble with that type of construction. We immediately increased the lap to twelve inches, and have only an occasional triangular crack at the lapping of the bars. We are now considering the reducing of the size of the bars and using a greater number of them, which I think is better construction.

MR. JACKSON: I was interested of course in comparing your design with that of Illinois where they use the shear bar or so-called greased and oiled bond which is not bonded with the concrete,—an entirely different practice in the two states.

MR. TEBBS: I have discussed that point with some of the men who have used it, and am informed that the unbonded bar is not free in all cases.

WALTER E. ROSENGARTEN, Traffic Engineer, The Asphalt Association: While there seems to have been more or less difference of opinion this afternoon in regard to concrete bases for asphaltic tops, I believe that the consensus of opinion was in favor of the old practice of a 1-3-6 mix, possibly 6″ in depth. There are so many service records of pavements of that depth and mixture that undoubtedly there is some reason for this extensive use and adoption. If we stop to study the reasons we find several very definite ones. In the first place, the lean mix, has less expansion and contraction, due to temperature, and also moisture changes, and has a lower tensile strength. With the lean mix, fine hair cracks form in the base which do not affect the surface of an asphalt pavement. When the richer mixes are used, there is greater expansion and contraction, greater tensile strength, and the cracks that form will be further apart, and being further apart, they will be much wider. These cracks will break through the surface of the asphalt pavement, and give more trouble than do fine hair cracks in a leaner mix base. With the lean mix concretes, we are more likely to get a roughened surface on the base. While there is a difference of opinion as to whether that is necessary, I think it is somewhat of an advantage in giving a bond for the asphalt top.

It would be interesting to mention a word or two about joints in portland cement concrete bases, under asphalt tops. The general practice throughout the country has been to eliminate the joint, just as Mr. Tebbs told us is the practice in Pennsylvania. However, that is a question that has puzzled a number of engineers, and it has been tried out. I think that when joints have been put in concrete bases, it has more generally led to trouble with the surface than when the joints are omitted. The joints are frequently filled with bituminous material, and when the base does expand, that bituminous material is forced up from the joint, and raises the pavement, causing a hump. The most general practice throughout the country has been to eliminate the joint in a concrete base.

The question of reinforcing in a base was discussed. In view of the success that we have been attaining with the plain concrete bases, it is hardly advisable to introduce the reinforcing which gives considerable trouble when cuts are made, which is a vital question in city paving.

New York City, as Mr. MacGregor said this afternoon, has an average life of eighteen years for their asphalt pavements before resurfacing is necessary. Washington, D. C.'s record is something over twenty-five years. Buffalo, N. Y., Columbus, Ohio, and others have similar records.

The question of economics is something that should be considered in this connection, if we are going to try to improve on the present usual construction. We learned this afternoon, for instance, an increase in the depth of the base of only two inches increased the cost $10,000 per mile. I am sure that $10,000 could be spent to better advantage to give a pavement of longer service, by putting that money in the treatment of the subgrade. Failures that occur are quite frequently in isolated spots. Therefore, if we will pay particular attention to those isolated spots where there is trouble, possibly putting in an insulation course, as we might call it, of an inch or two of sand or gravel, at much less expense, we would get better results.

There has been discussion of the beam strength in bases. I would like to put in a very strong word against the theory that we have to design all our pavements for beam strength, especially pavements with asphalt tops. A small crack in the base will not come through to the surface, and, while there is no beam strength the pavement is not necessarily ruined by the hair cracks in the base. Engineers like to figure along the lines of the old formula of $M=\frac{S\times I}{C}$

When we have material that will answer that formula, it is much nicer, and more interesting to the engineer, to figure on beam strengths than when we have a plastic material such as the asphaltic mixtures.

In this connection, I would like to say a word or two about the asphaltic concrete, or black base, that is being adopted quite generally throughout the country. We have long service records where black base has been used under asphaltic pavements and also under other types, such as brick. There is a brick pavement in Trenton, N. J., that has an asphaltic concrete or black base. Washington, D. C., has some black base pavements that are fifty years of age. Savannah, Georgia, has laid all of its asphaltic pavements the last two years on asphaltic concrete bases. Denver, Colorado, in the last few years, has laid over a million square yards of black base. Pittsburgh has, I think, up in the hundreds of thousands of yards of black base. So I could go on and name a good many other cities that have large yardages of black base that have been giving good service. In fact, black base was used before Portland Cement concrete base. Then there was a time when the Portland cement concrete base came into use owing to it being somewhat less expensive. As time went on, and as the less expensive petroleum asphalts were adopted, the cost of black base became somewhat less and at the present time it can be laid at about the same cost as concrete base. In fact, being non-rigid, black base can be laid even thinner than Portland Cement concrete bases and give very satisfactory results. For instance, the Denver streets have a three-inch macadam base, or insulation course of the old macadam, on which is placed 2½" of black base, and an inch and a half of asphaltic topping. From this you will note that the use of black base is by no means an experiment, and is being successfully adopted. A number of places have included it in their regular standard specifications. The cuts through a black base are very easy, and it can be replaced by the same gang that places the surfacing, it can be opened immediately to traffic, and also makes a very serviceable filling for cuts through concrete bases. When there is a settlement at a cut, or even in the pavement itself, with the concrete base there is an actual structural failure, and a sinking down. In the case of a black base, there is a sinking down, but there is no structural failure. The pavement is just as sound after that depression has formed as it was prior, and a skin patch can easily be placed over the depression and the pavement then is in as good condition as at the time of original construction. There are many advantages in the use of a black base not only for an entire pavement, but also for replacing cuts.

It might be of interest to note that the report to the International Road Congress last year, in Milan, of a number of English engineers, including those from the cities of London, Sheffield and Bristol strongly recommended the elimination of concrete bases under their pavements and the introduction of black bases. They have service records that indicate that asphalt pavements have been giving longer lives on the black base than on the Portland cement concrete base.

MR. LYON: The last speaker mentioned that the 1-3-6 or lean mix on a 6" base was the consensus of this meeting. From the papers I have heard read, I hardly believe that that is entirely true. I can hardly reconcile myself to that attitude. I hope it is not entered on our records in that way.

I am also unable to reconcile his statement that a lean mixture prevents cracks. And the furter statement that beam design is not necessary because the crack doesn't matter. I would like to know just what his analysis of the two statements might be.

MR. ROSENGARTEN: In connection with the cracks in the lean mix bases, with less expansion and contraction and with less tensile strength, we will have openings at a number of places. These will be fine hair cracks which will not pull apart sufficiently to break through an asphalt surface. A richer mixture with its greater tensile strength, will not break at as many points, but with the greater expansion and contraction, will pull apart further, and form a wide crack in the base, which will tear the surface.

MR. LYON: Why the necessity of a lean design against cracks?

MR. ROSENGARTEN: I think the resurfacing of old macadam roads with asphalt tops is an excellent example of the success where we do not have rigid strength. We have resurfaced throughout this whole country many miles of old Macadam and gravel roads. I think there is a strong feeling among engineers that an old macadam base is equivalent to a new concrete base. We will agree that you can not compact a new stone base as thoroughly as an old macadam road is compacted, and we will not get as good service from it. Therefore the addition of sufficient Portland cement to make that loose stone more stable will make it satisfactory for a base for an asphalt pavement. But I do not feel that it is necessary that we make a rich rigid base.

MR. LYON: I still don't see the connection between the macadam base reinforced by concrete grout and an original concrete section being designed.

MR. ROSENGARTEN: We are getting excellent results on that design throughout the country, and it is quite generally felt to be equivalent to a concrete base. Therefore if these fine hair cracks form in a lean mix concrete base, we needn't say that the pavement has failed, and there is no service in it. The sub-soil is supposed to carry our load. We simply need to distribute that load over the sub-soil sufficiently so that there will be no hole punched in it. If we can maintain contact with that sub-soil and the thickness of the pavement is sufficient to distribute the load over a big enough area, then we will get satisfactory results. I simply can back up the statement with the extensive use of 1-3-6 bases 6" thick and the success that has been obtained with them. In the cities I mentioned, for instance, in New York, in Washington, and these other cities, the majority of the yardage that is giving such long periods of service, is on lean mix bases, and I dare say you would find that there are cracks in these bases, and yet they are giving satisfactory results.

MR. SKILTON: Not getting into the discussion of 1-3-6 vs. 1-2-4, we might perhaps bear in mind that in late years, with the tremendous increase in traffic, the tendency is to so design your asphalt mix that it is considerably harder than it used to be made, approximately the main feature being the heavy traffic, another feature, better surface with less waves in it.

I would not say that under every crack in asphalt there was a crack in the concrete. I do not think it possible that a crack in the asphalt is due to contraction in the asphalt itself.

MR. POLLOCK, of New York: In regard to the cracks in the asphalt pavement, I have investigated a good many of them, and I have invariably found a crack underneath through the concrete base, usually a good sized crack. It has been my experience that with the leaner mix of concrete, 1-3-6, that you do not get as large cracks, you get more small hair cracks which do not as a rule carry through the asphalt surface.

COLONEL COMPTON: If the chair may be permitted to make a few remarks, it has been my experience over a period of a great many years, in the laying of six million yards of bituminous asphalt pavement, that invariably you will find a crack in the base. Where it does occur in the top and not in the base, it is usually caused by using asphalt of too hard a mixture, or something of that sort.

WILLIAM C. PERKINS: Twelve years ago, at a conference of highway engineers at Cornell University, I prophesied that sometime (and I hoped that I would live to see that day) we would design our pavements as we design bridges and other engineering structures. From what I heard tonight I think we are coming to that, and that some formula may be developed by which we can design foundations and pavements.

The integral parts of any pavement are two, the wearing surface and the foundation, and by the foundation I mean the sub-grade and the artificial foundation. In other words, our sub-grade is as much a part of our foundation as our artificial foundation. For in some sections of the country, we lay our wearing surface directly on the sub-grade. The sub-grade of any pavement or highway should be thoroughly investigated, and if possible we shoud maintain it at a maximum stability by proper drainage and other necessary treatment. The artificial foundation may then be substantially reduced in cost.

The flexible type of artificial foundation, like gravel, rolled stone, black base, etc., will be suitable and economical in transmitting the loads to well constructed sub-grades. On the other hand, where it is not possible to maintain the sub-grade at maximum stability, it may be found that a concrete foundation will be the most economical.

The fundamental principles of road construction, as laid down by our old friend Macadam, are as follows:

"That it is the native soil which really supports the weight of traffic; that while it is preserved in a dry state, it will carry any weight without sinking, and that it does in fact carry the road and carriages also; that this native soil must be previously made quite dry and a covering impenetrable to rain must then be placed over in it that dry state; that the thickness of the road should only be regulated by the quantity of material necessary to form such impervious covering and never by any reference to its own power of carrying weight."

Careful analysis will demonstrate that his theory was and is sound, although under present traffic conditions it will probably be necessary to take additional precautions to preserve the subgrade in the desired dry state.

While it is fully recognized that peculiar local conditions will greatly affect the design of a pavement structure, in general it will be found that economical construction can be accomplished only when full realization is had that the function of the subgrade is to carry the weight and impact of traffic, as imparted to it through the superimposed wearing surface.

The wearing surface of a pavement is more or less standard; however, the foundation may be constructed of a wide variety of materials and may be of varying degrees of thickness, the fundamental consideration being that the subgrade shall be stabilized in so far as local conditions, requirements and prices will permit. The foundation, whether rigid or flexible, or of whatever materials composed, should be designed to meet the particular subgrade conditions which investigation may disclose can be maintained, and the thought should be kept clearly in mind that true economy in construction of the foundation requires that any investment in creating a stable subgrade shall be more than offset by the saving in foundation cost.

To sum up, research data is vitally important in the development of an economical pavement design, but its greatest value is possible only when it is carefully considered in the full light of successful construction in the past.

The stability of the subgrade affects not only the design of the foundation, but also the pavement as a whole, and therefore subgrade treatment is one of the first and most important considerations.

Local subgrade conditions and character of traffiv should properly govern the design of the foundation. In general, flexibility in the foundation permits the best development of the supporting power of the subgrade.

COL. R. KEITH COMPTON, Chairman: Before this meeting closes, I would like to express, as a member of the committee, our congratulations to Mr. Adler, the General Chairman, and the officials of the Engineers' Club of Philadelphia for such a delightful and enlightening conference. Even though we may differ at gatherings of this sort, it is an honest difference, and we all go back remembering what the other fellow said, and it means something to us.

And in closing the meeting, I would ask Mr. Adler, as General Chairman, to close the meeting.

MR. ADLER: I appreciate the courtesy of the officer of the evening in turning it over to me.

In closing, I feel I have had ample opportunity this afternoon to intersperse my views among the discussions of the day. I hardly feel justified in taking up very much more of your time, but I do wish that some of the other men who are here whom I am sure haven't availed themselves of the full opportunity to express their views can do so. If not, I will attempt to do what Colonel Compton says, to wind up the meeting with just a few minutes outline of the discussion, bearing in mind that though there are apparently differences of opinion that have been expressed today that are difficult to reconcile at this moment, that I believe that when the full discussion of the meeting is reprinted in ENGINEERS AND ENGINEERING, and becomes available for general perusal, that we will find that those differences are differences not entirely irreconcilable. There has been a great deal of valuable light shed on subjects which do not meet with general unanimity of opinion among the representatives of various municipalities and highway organizations. The thought has occurred to me (and this is really one thought that I have gathered that I think is worth emphasizing in closing the meeting), that discussion by representatives of different localities has clearly brought out the necessity for more flexible handling of the foundation situation, not only in different towns, but in different sections of the same town, and at different periods of the year in the same locality. For example, Mr. Butterfield called attention to the fact that within a reasonable period of time concrete laid in very cold weather showed at 28 days not more than 50% of the strength of concrete laid under normal working conditions and normal temperature conditions. We know, as a matter of fact, that pavements completed in November, December, or early January, as is not infrequently the case in big cities, can not be kept barricaded from traffic until the following spring, and that they may, and frequently will, be subjected to heavy truck and bus traffic within a comparatively short time after their completion. It seems evident, in order to fully protect such pavements from disintegration in their early history, that special means ought to be adopted to give them additional strangth as compared to whatever may be the general standard for that particular town.

We further know that ditches that are back filled in the latter part of the working season, when perhaps frost or freezing conditions prevail, are surely not going to be as well solidified as ditches that are back filled in the early spring and allowed to lie perhaps over the summer through the summer rains, and with a limited amount of traffic over them, with the paving perhaps following three or four months later. It seems, then, that in the average municipality the present standards tie us down to a very narrow range of variation in our design of foundation, and that that is perhaps the most serious handicap that now confronts the paving engineer. In the same connection, Mr. Lyon, of Pittsburgh, suggested the fact that in a State like Pennsylvania, where the State law requires that the cost of original paving shall in all cases be assessed against the property owner, that it is unfair to the residents of a street which is designed, or expected, to become a thoroughfare and receive exceptionally heavy traffic, as compared perhaps to a street right around the corner which is never going to have more than ordinary local traffic, it is unfair to assess the property owner with the very considerable additional cost which would result if, because of that expected heavy traffic, or because of late season work, or what not, it was concluded by the engineer that the foundation for that particular street should be thicker or richer in composition or even reinforced. It seems, then, that we are handicapped not only by the range of flexibility of our own specifications, but in a State like Pennsylvania we are further handicapped, in the desire to progress and to improve the situation, by a law which would impose upon the property owner a burden which is purely an engineering matter, and not one for which he is primarily responsible since the property owner in general, and certainly in residential sections, is not interested in having a street which is going to become a traffic thoroughfare and is certainly generally not interested in the fact that it might be much more expensive to construct a durable concrete foundation in the latter part of the season, than one constructed under normal working conditions in the early part of the season.

I am stating to you just briefly some of the thoughts and conclusions that have flashed in my mind as I have listened to the various discussions, and I think if anything can be accomplished by a meeting of this sort, by the interchange of ideas brought out in discussion, it can be accomplished by afterwards taking the full discussion of the meeting and making a careful comparison of the views expressed, and seeing whether they lead to any conclusions for betterment.

The Carquinez Strait Bridge

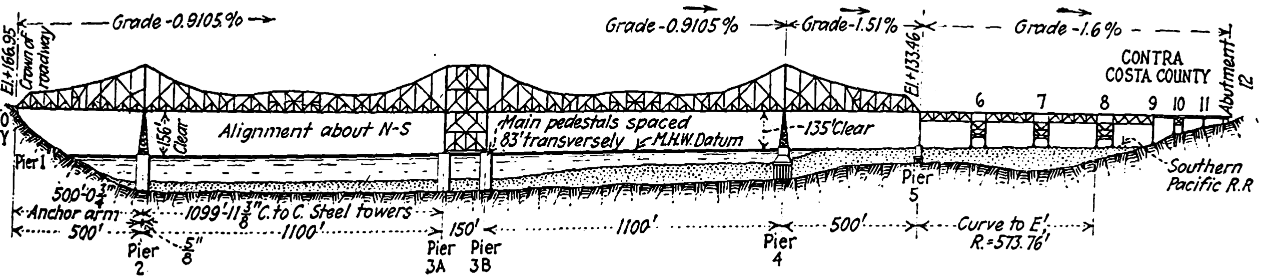

FIG. 2—GENERAL DRAWING OF CARQUINEZ STRAIT BRIDGE

Design

By D. B. STEINMAN

ON MAY 21st, 1927, there was celebrated the official opening of the Carquinez Strait Bridge. That marked an important event for traffic in California because it overcame a barrier of centuries. Coming down their respective valleys are the Sacramento and the San Joaquin rivers, forming a junction as they flow into Suisun Bay, then through Carquinez Strait into San Pablo Bay, then through San Francisco Bay and out through the Golden Gate into the Pacific Ocean. This chain of waters has constituted an effective barrier up to the present, impeding traffic between Northern and Southern California, holding back the flow of traffic between the Bay Cities near San Francisco and the country to the north. Four years ago or more the plan was conceived of conquering this barrier by building a bridge across the narrowest point—Carquinez Strait.

The main structure is 3,350 feet long, the approach viaduct is 1,132 feet long, making the total length of the structure 4,482 feet. Total cost approximately $8,000,000, making it the largest investment to date in a private toll bridge enterprise. The two main channel spans are 1,100 feet each. These are the cantilever spans; to anchor them down there are provided two 500-ft. anchor arms, one at each end; all these spans combined with the central tower span of 150 feet make up the total length of 3,350 feet for the main structure. The under-clearance required for navigation was 135 feet at the minimum point, and this height of the steel above the water, by virtue of the grade of about 1 per cent, becomes over 150 feet at the other end of the structure.

A comparison with previously built record-breaking structures, including the Queensboro Bridge in New York, the Delaware River Bridge,* the famous old Brooklyn Bridge in New York and the Quebec Bridge, shows the Carquinez Bridge to be one of the ranking structures of the world. This project was conceived by A. J. Hanford. He was a man of achievement although he did not have the benefit of a college education. He started as a grocer in these San Francisco communities, developed a ferry crossing the Carquinez Strait, and conceived the plan of replacing the ferry with this bridge in order better to take care of the traffic requirements. It is one of the tragedies of this story of the Carquinez Bridge that Mr. Hanford, after overcoming all of the opposition, after fighting the difficulties for years, did not live to see the consummation of his vision. He died about six months before the work was completed. He was the president of the company formed to build this bridge—The American Toll Bridge Company. Figure 2 shows general data and pier numbers. Pier 5 supports the rocker tower at the junction of the main structure and the viaduct. This viaduct is on a 10-degree curve, in order to make the desired connection with the highway. In addition to the curvature, a skew layout had to be provided for the crossing of the main tracks and sidings of the Southern Pacific Railroad, and this combination of curvature, skew, grade and super-elevation (to compensate for the curvature) made some rather mean detailing and computing for the engineers. The piers, incidentally, constitute one of the outstanding features of the project, particularly Piers No. 2 and No. 3, for they are, I believe, the deepest-water piers in America, if not in the world. In addition to 90 to 100 feet of water and 40 or 45 feet of river bed material before we struck rock, we had to contend with the additional problems created by a current of 7 miles an hour and a tidal range of over 8 feet.

Pier No. 1, an abutment, is the north cantilever anchorage. It was built on a steep hillside, having a slope of about 45 degrees, and was founded on a natural sandstone foundation. On the bridge seat of this abutment is the wind-bracing anchorage which was the first steel work to be built. This wind-anchorage takes the reaction of the lateral system or wind-resisting system of the structure, and is provided on the sides with bronze bearing plates which abut against brackets on the under side of the end floor beam; this construction is designed to permit longitudinal movement of the end of the bridge while resisting transverse or lateral movements.

Pier No. 4, which is the main support of the South Cantilever is founded on reinforced concrete piles, upon which the concrete was built within a cofferdam. Tremie concrete, over 10 feet in depth, was placed as a seal layer, permitting the unwatering of the cofferdam and the placing of the remaining concrete in the form of two separate pier shafts (see Figure 3). One of the difficulties encountered in this work was the attack of the teredo. After the crib for this cofferdam was built, launched and lowered into place, precautions had to be taken to protect it against the insidious attack of these marine borers, and this proved to be a very real problem, on account of the small run-off of the streams that year resulting in an unusually high salinity of the water in the Strait. Every possible precaution was taken to protect the timber. Tarred felt was placed over the surface and additional planking on top of the tarred felt. Plates were placed a short distance away from the outer walls and the space between was dosed with poisonous copper sulphate solution. The teredo is so active in these California waters that it has been known to destroy a timber structure in 90 days, and piles have gone to pieces in six weeks. In this case, despite all precautions, the bottom of this cofferdam was badly attacked and rendered so porous that there was considerable wash of the cement out of the tremie concrete. As a result, on three successive attempts to unwater the cofferdam, the tremie concrete blew up. Finally after increasing the depth of the seal layer of concrete, the crib was unwatered and the pier was completed.

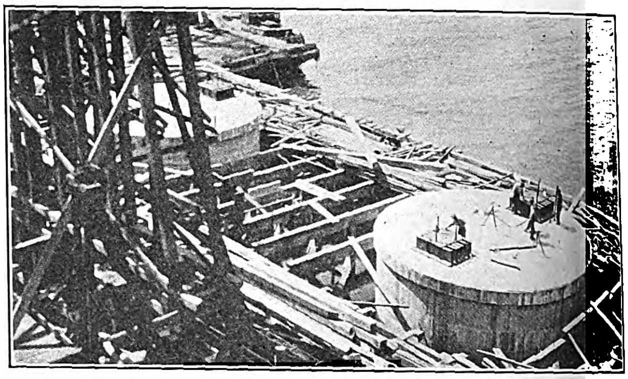

FIG. 3—PIER NO. 4

The most difficult problem was the designing and building of the piers in the middle of the stream, Piers No. 2 and No. 3. Various alternative designs were made. One of the first designs was a steel shell for open dredging, with inner and outer walls separated by bracing, and providing for a central dredging well; this shaft was ultimately to be plugged up with a concrete seal, at the top and bottom, leaving a hollow intermediate space to reduce weight. Weight reduction was an important factor, because the weight of a solid cylinder of concrete 140 feet high is no inconsiderable item. It was planned, after careful floatation studies, to float the cylinder out, up-end it, and guide it into position by means of a guide-frame previously placed. Such guide frame was essential on account of the swift current in the Strait. An alternative design was made with a reinforced concrete

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*See ENGINEERS AND ENGINEERING, September, 1926, page 254.

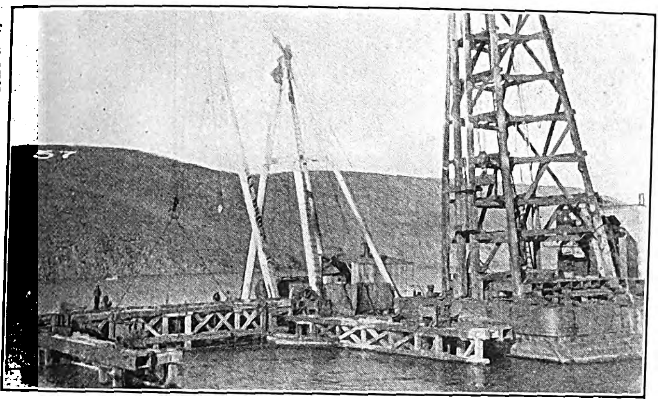


FIG. 4—GUIDE FRAME FOR CAISSONS OF PIER 2 AND 3

shell. This was to be provided with a central dredging well and four circumferential wells, and with a false bottom designed to be quickly removed after the caisson reached bottom, to permit its penetration of the soft material overlying the rock. In this case, again, it was planned to plug up the working chamber and parts of the central dredging shaft, and to fill the outer dredging wells with a special light-weight concrete. We spent months on these various studies.

A third design, which was the one finally constructed, was a timber caisson. This was adopted because it was felt that it offered the smallest risk, requiring the smallest factor for contingencies to be figured by the contractor. This caisson design was of comparatively solid construction, leaving four main dredging wells. The outer wells or chambers in the timber grillage were to be filled with concrete to give it weight for sinking. Cutting edges shod with steel were provided around the bottom edges. Special precautions again were taken against the Teredo. Around the entire outer surface was placed a lining of tarred felt, with planking on the outside of this lining. In addition, as a further precaution against teredo action, the main columns or studs above the groundline were made not of timber but of reinforced concrete. The framing within the caisson fitted into these reinforced concrete posts so that, in case of the outer layer of timber (despite the tarred felt and other protection) was destroyed by the teredo, there would be this outer surface of concrete to form an effective barrier between the teredo and the essential timbers in the interior of the structure.

Each cutting edge was made up of a solid construction of 13 tiers of 12 x 12 timbers. A complete jetting system was provided, including friction-relief nozzles on the outside, and cutting nozzles on the inside to loosen the material and drive it toward the dredging buckets at the center of the wells.

To guide the caissons in their sinking, a guide-frame system was developed and adopted. This guide frame system included steel columns or spuds, reaching down through the 90 feet of water and 22 feet of the material below. These columns were braced together with girders, both horizontal and vertical, to give a complete system of bracing in all directions, and the resulting guide frame was anchored to heavy anchors at the four corners, each anchor weighing 16,000 lbs. One side of this guide frame was left open, the caisson was floated in, and then the fourth side was placed completing the enclosure. (See Figure 4.)

There was no trouble encountered except in the case of the very first caisson which, after it had entered the bottom of the Strait, suddenly tilted 13 feet out of plumb. Heavy shackles were placed around it and anchored and, by reducing the jetting on the low side and accelerating the jetting and dredging on the high side, the crib was righted and brought into accurate position. In spite of all these difficulties, these piers were sunk through the tide and current, through the 90 feet of water and 45 feet of underlying material, with hardly a perceptible error in their final placement. After these 40-foot square caissons reached their upper level, they were surmounted with cylindrical pier tops 34 feet in diameter.

Six such piers had to be sunk in this deep water, two of them for Pier No. 2, and four for Pier No. 3. The guide frames and the forms were used over again for successive piers.

After these piers were completed, they served the function indicated in Fig. 5, two of them at Pier No. 2 supporting the North cantilever structure, and 4 of them at Pier No. 3 supporting the central tower. These piers are spaced 83 feet center to center, transversely; at Pier No. 3, the piers have the same transverse spacing but longitudinally are spaced 150 feet center to center. Their copings are about 10 feet above water level, and above that point the steel rises about 150 feet to the floor of the bridge, and then an additional 168 feet to the top of the tower, so that the total height is about 460 feet from the foundations to the top of the steelwork.

I have endeavored to cover the high spots in the design of the sub-structure, and will now proceed to review some of the outstanding features in the design of the superstructure. You will observe that outside of the central tower, the other supports of the main structure appear comparatively unbraced. There is but a single tapered tower (No. 2) supporting the northerly portion of the structure, and a similar tower (No. 4) supporting the southerly portion of the structure. There is an anchorage to the abutment on rock at the north end, but at the south end no satisfactory horizontal anchorage was available. On account of the limitations imposed by the clearance requirements of the Southern Pacific tracks, a tower could not be built; instead a rocker bent had to be built, as narrow as possible, so as not to encroach upon the right of way. The bridge could not be made structurally continuous from end to end, since provision had to be made for expansion joints. A minimum

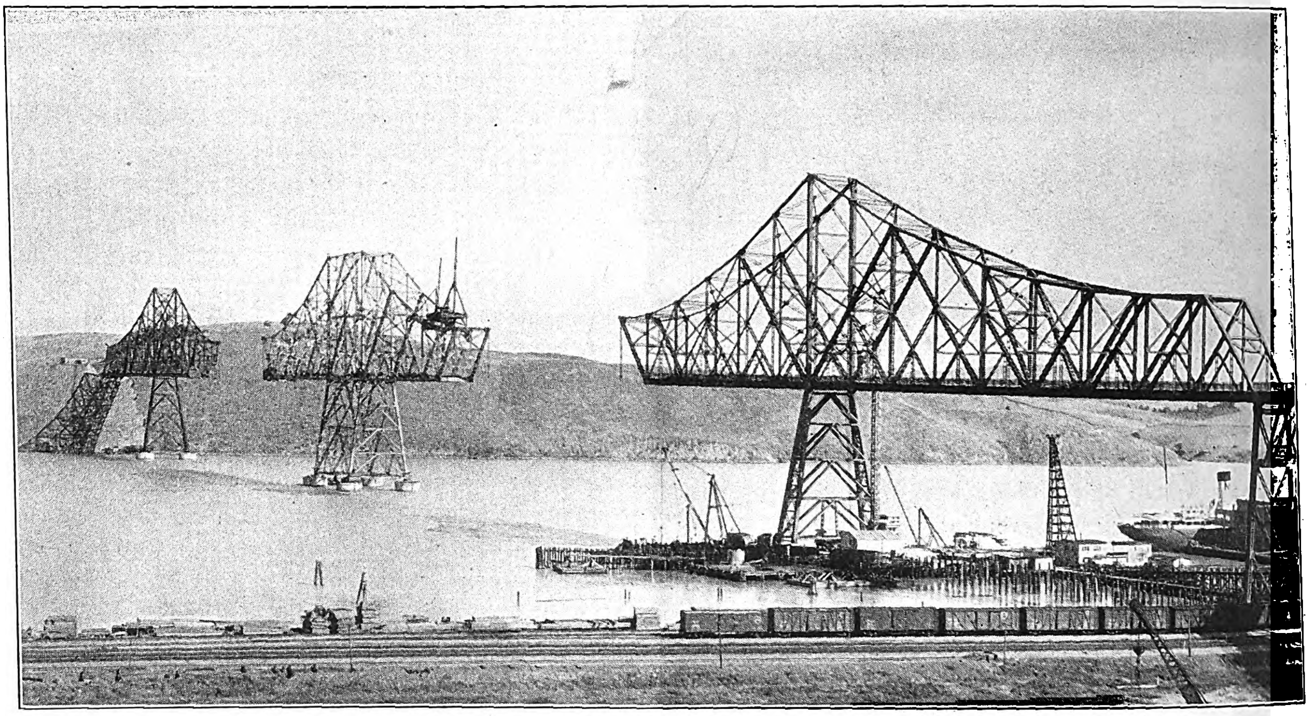


FIG. 5—BEFORE CENTRE SPANS WERE PLACED

of four expansion joints had to be provided: one at the northern end of the north suspended span, and one at the southern end of the south suspended span, each being an 11″ expansion joint; a 5″ expansion joint at the north abutment, and a 5″ expansion joint at pier 5. These expansion joints divided the structure into three separate units, the central one having a braced tower support, and the others having only slender tapered tower supports. Remember that California is an earthquake country, the citizens of San Francisco to the contrary notwithstanding, and it was necessary to take such precautions as we could despite these difficulties to make the structure as safe as possible against earthquake effects. We made a study of the constants and coefficients observed during the 1906 earthquake (or "fire" as they prefer to call it), and on the basis of those constants we figured the earthquake forces that might act on the structure. To provide for such emergency, we decided to tie up the different sections of the structure into a single longitudinal unit in the event of an earthquake, and for this purpose expansion stops and hydraulic buffers were placed across all expansion joints,—so as to limit the amount of possible movement to that required for temperature expansion and contraction, and also to stop and arrest all movement if that movement were sudden in its effect.

In the design of the bridge, three different kinds of steel are used: Silicon steel was adopted for the main built-up members in the structure. Heat-treated carbon steel was adopted for eye-bars forming the principal tension members; this was the mild or medium grade of heat-treated steel, having a minimum yield point of 50,000 lbs. per square inch. For the silicon steel we allowed an increase of 40 per cent over the working stresses allowed for ordinary steel; for the heat-treated eye-bars, we allowed an increase of 50 percent over usual working stresses. Ordinary structural carbon steel was used for details.

With the use of the eye-bars, special connection details were developed for connecting the web members and bottom chord members at the lower chord panel points of the suspended spans. Instead of having a single central pin for the connection of the members, two separate pins are used, one for the connection of the diagonals, another for the connection of the bottom chords, and, although each of these pins is off center with respect to the center of the connection, nevertheless each pin is on the center line of the respective stress for which it serves. This yielded a novel, compact, and simplified detail, permitting a simple connection of the floor beam without the interference of eye-bar heads and pins.

At the tops of the tapered towers Nos. 2 and 4, a special multiple pin detail was adopted. If all the members at such a point were riveted together into a common connection, it would be a point of very serious secondary stress. At a corresponding point in the Sciotoville Bridge (over the Ohio River) we figured a secondary stress of over 20,000 lbs. per square inch no matter how big the sections of the members were made. At such a junction point of an anchor arm and cantilever, some special provision is necessary to eliminate or reduce the secondary stresses. Such provision is afforded by using a multiple-pin detail, thereby eliminating the dead-load secondary stress. However, it was necessary here also to provide for possible earthquake effect. To prevent the structure from being shaken into its component parts by an earthquake, a hinge plate is provided across each pin, each hinge plate being riveted to the member on the other side of the pin. These hinges were not riveted to the member on the other side of the pin. These hinges were not riveted until the deadload was on the structure, so that the riveted connection did not interfere with the adjustment of the members to the deadload secondary stresses during erection.

The wind anchor on the north abutment (Pier No. 1) permits a longitudinal expansion of five inches required for the 500-foot span, while at the same time carrying the entire wind reaction from the trusses above, down through this steel work into the masonry of the abutment.

As the structure was built out from this north abutment, the span approached Tower No. 2 which was waiting to receive it.

The structural detail at the junction with the abutment is called the Lo point of the anchor arm. Figure 6 shows the provision for anchoring this end of the truss into the masonry, also the special adjustments that had to be made for the connection of the span to Tower No. 2. Special uplift jacks were provided above this Lo point (four 500-ton hydraulic jacks), and two 500-ton jacks under the end floorbeam for further adjustment.

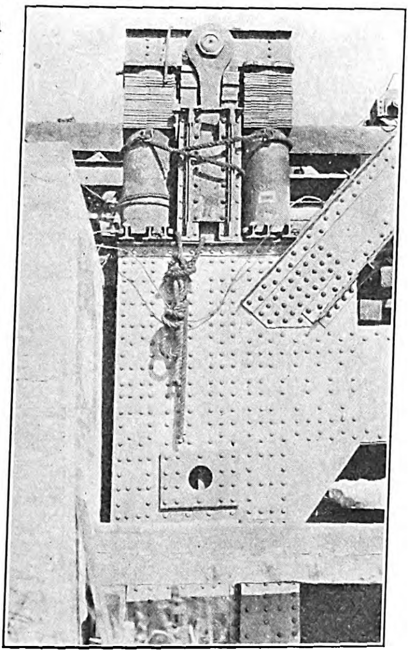


FIG. 6—STRUCTURAL DETAILS AT NORTH ABUTMENT

Instead of the conventional X-bracing system, in the towers, we adopted the triangular or K-system which gave advantages in economy of material and facility of erection. The same general principle of securing the economy of triangular or K-bracing was carried out in other parts of the design.

The top chord members, near the towers, are eyebars, and beyond those points they are built-up members.

At the South end, the viaduct was built first, then the south cantilever arm and Tower No. 4, the latter being similar to and symmetrical with Tower No. 2 which I have just described.

At the same time, in mid-span, the main central tower was being erected. This central tower, after reaching the floor level, was built up two additional stories above roadway level. In this tower, we have another application of the triangular system of bracing, in this case subdivided so as to support the members against sagging.

The main panels of this Tower Span were made 37½ feet long, dividing the 150 feet into four panels. This panel length was found preferable to an attempt to carry through the same panel length that obtained in the other parts of the structure.

From the central tower, a cantilever arm was built out on each side, finally reaching the stage where it was ready to receive the suspended spans at the two ends. The length of base is only 150 feet. (See illustration on front cover of this issue.)

This tower span of the Carquinez Bridge corresponds to the anchor span in the case of the Queensboro Bridge at New York. For the Blackwell's Island or Queensboro Bridge, the corresponding length of base, instead of 150 feet, was made 630 feet, and there the builders had the advantage of an island in the middle of the river (Blackwell's Island) with rock practically at the surface forming a simple foundation problem, requiring merely the building up of two masonry towers on the island and erecting the span on falsework between them. In the case of Carquinez, however, there was more of a balancing problem because, instead of rock near the surface, the piers did not have the benefit of a supporting island but had to go down through deep water to minus 132 feet before they could hit rock. In addition, the central tower span of 150 feet had to afford the base for the unbalanced strains of lifting the suspended span on one side at a time. About 700 tons of steel had to be lifted, plus the compensating counterweights, all on one side, with nothing on the other side to counteract this load. To permit this lifting, special anchorage provisions had to be made on the far side of the main tower.

The viaduct approach was built on a 10° curve, and consisted of truss spans and tower spans alternating. Odd design features and details were necessitated by the combination of curvature and skew; in fact, there were hardly two floor beams or stringers alike in the curved portion of the structure.

As one of the consequences of this curvature and skew combination, floorbeams had to be used with a large part of their length projecting out in cantilever fashion beyond their supporting towers.

To compensate for the cenrifugal force, superelevation was provided on the roadway, making the outside of the curve seven inches higher than the inside; special concrete haunches were built up to provide this superelevation, with anchor bolts going through the stringer flanges. In addition to the superelevation, the roadway was widened, on the curve, from 30 feet between curbs to 32 feet between curbs, giving another complication to provide for in the detailing.

At the North end of the approach viaduct is a rocker bent, Tower No. 5, which is the junction of the viaduct and the main structure. This bent had to be kept narrow on account of clearance restrictions at a point where we would very much have liked to use a braced tower of substantial base. Pin connected at the bottom and at the top, holding down the end of the main structure and supporting the end of the viaduct, this rocker bent has to rock five inches with thermal expansion and contraction of the 500-foot anchor span.

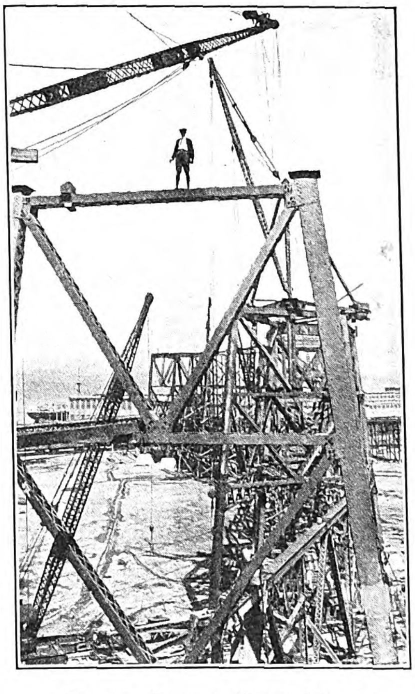


FIG. 8—ROCKER BENT NO. 5

Fig. 8 is from a photograph of this rocker bent No. 5. Note that again we followed the triangular or K-system of bracing. The main structure is pin connected at the top and, on an intermediate girder, the viaduct truss rests on roller bearings. For these roller bearings, an interesting and novel feature was introduced: Instead of the usual single roller nest, a double roller nest had to be provided, one above the other and at different angles, because of the curvature of the approach. The approach span is not in the same lines as the main span and, consequently, as the tower moves back and forth with the expansion and contraction of the main structure, there is a different direction of relative motion for the approach span. In consequence, two roller nests had to be provided, one superimposed upon the other, with an angle of some nine degrees between them, the lower roller nest being in the direction of the main span and the upper in the direction of the approach span.

From this Tower No. 5, the erection proceeded to Tower No. 4, the main cantilever tower. At this Tower No. 4 is one of the multiple-pin shoes previously mentioned.

Fig. 9 shows Tower No. 4, with one of the multiple pin shoes in place and another one being lifted into position.

Fig. 10 is from a photograph of the pin-shoe, giving an idea of its size and proportions, also showing the hinge plates for earthquake provision.

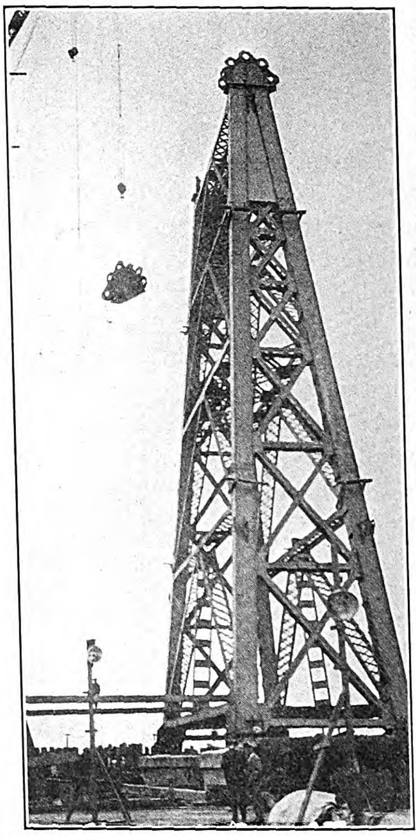


FIG. 9—TOWER NO. 4

The next feature of interest is that of the suspended spans. With the South cantilever arm built out from the viaduct approach on the south shore, the north cantilever arm coming out from the north hillside, and the central tower span erected with its two cantilever arms, two gaps were left to be closed by means of the suspended spans. At the commencement of the design of the bridge, economic studies indicated the desirability of a curved top chord for the suspended spans. It yields a material saving in cost and, in our opinion, the most satisfying treatment from the viewpoint of appearance. In some bridges, the attempt is made to camouflage the suspended span, sacrificing economy for a certain doubtful artistic effect; but we believe that the best aesthetic effect is secured by carrying out the principal of truth in structural design.

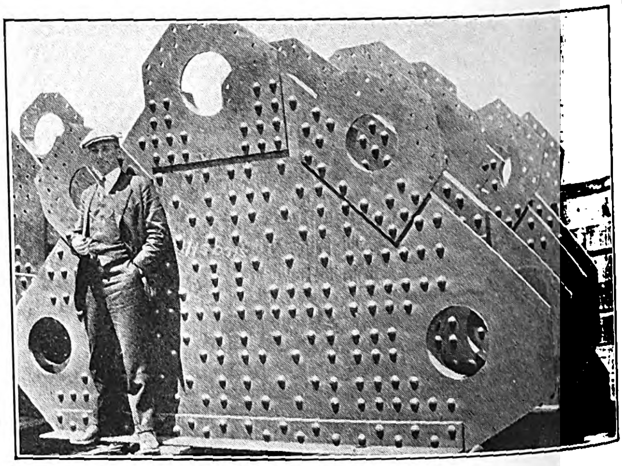


FIG. 10—MULTIPLE-PIN SHOE

In the case of the Queensboro Bridge in New York, the problem of the suspended spans was solved by eliminating those spans. There are no suspended spans in the Queensboro Bridge. The two cantilever arms were built out from the two sides of the channel

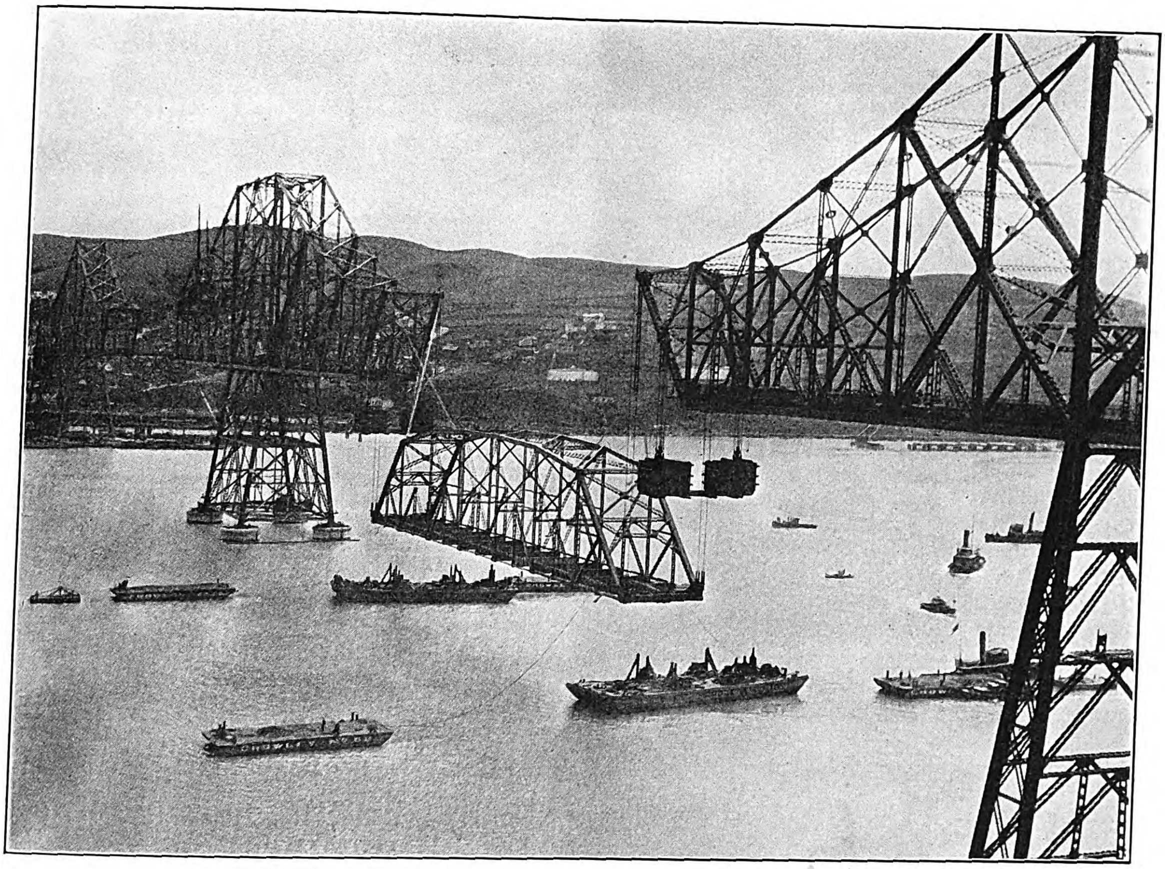


Fig. 11—Raising a Suspended Span

until they met at mid span and were coupled together. One of the governing reasons may have been the desire to simulate in the top chord outline the cable curve of suspension bridges, to be in harmony with the other East River bridges. Another reason was to secure maximum structural rigidity, which it is claimed suspended spans tend to reduce.

In the case of the Quebec Bridge, a suspended span was provided. It was first decided to erect it by the cantilever method. The bridge was built out by cantilevering out over the St. Lawrence River, and this was continued with a part of the suspended span which was to meet the other half of the suspended span coming from the other side. Special toggle joints were provided to make the final adjustment when the two halves met. On the fatal date of August 29, 1907, something went wrong in one of the bottom chord members, and the whole structure suddenly crumpled, carrying down with it 100 lives. After investigations and hearings lasting several years, funds were appropriated for a new bridge, of revised design, more substantial, containing nearly 2½ times as much steel to carry the same load, and this time it was decided not to take the risk of the cantilever method of erection; instead the lifting method was adopted. The span had to be lifted a height of 150 feet. After it had gone up about 6 feet or so, something went wrong with the lifting mechanism, and the span suddenly dropped into the river with a loss of 13 lives. That was in 1916. The following year, however, a new suspended span was completed. It was lifted stage by stage with the use of hydraulic jacks. At the end of two days of the lifting operation, the span was finally and successfully connected in place.

These were the examples before us when we tackled the problem of the suspended spans for Carquinez Bridge. Remember that the Quebec disasters were the last previous instance of the building of a big cantilever bridge, and the thought was enough to give all concerned a certain "earthquake" sensation when we contemplated that precedent. The engineers of the American Bridge Company, however, developed a highly ingenious and novel method of lifting the span, floating it out into place and using counterweights for the lifting. In the last previous instance, the Quebec bridge, two days were required for the lifting operation and two disastrous failures occurred before the erection was successful: In the case of the Carquinez Bridge, lifting the spans by the counterweight method, there was absolutely no mishap. Everything went according to calculations; and the span was lifted in the actual lifting time of 35 minutes, in the case of the north suspended span on March 3rd of this year, and 30 minutes in the case of the south suspended span on March 19th. Those of us who were in New York felt tremendously relieved when we received the glad news by wire from California that the spans had been successfully lifted and connected in place.

Briefly to review the operation of the suspended spans: They were built on temporary docks, and jacked up on barges for flotation to position under the bridge.

The span proudly sailed up the strait with an escort of tugs, was connected to the lifting ropes, the counterweights were released, and the span went up like an elevator as the counterweights went down. (See Figure 11.) Finally the span was in position, the final connecting pins were driven, the bridge men waved their hats, steam sirens shrieked and 10,000 people on the shore threw their hats in the air; some of the latter were probably a little disappointed that nothing catastrophic had happened.

Fig. 12 is a photograph taken after the bottom chord member between the two spans was filled in. This is an interesting point, being one of the 11″ expansion joints provided for the thermal expansion. At this point, one of the special hydraulic buffers was provided to tie the two spans together into a unit in the event of an earthquake tremor.

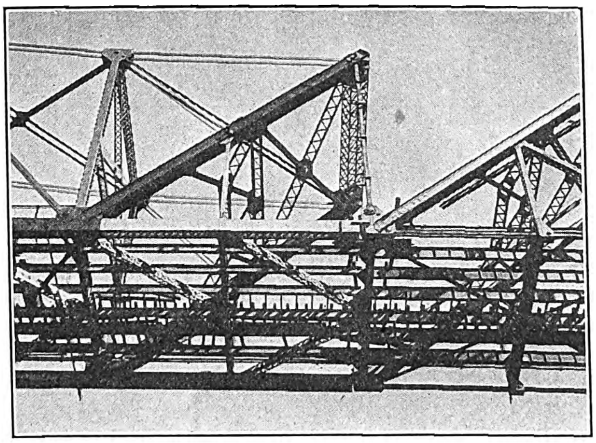


FIG. 12—PANEL POINT AT EXPANSION JOINT

Among the problems that had to be solved and met at each expansion joint were those taking care of the bottom lateral system and floor system across the 11″ expansion joint. The bottom laterals have sliding connection at this point on a gusset attached to the end floorbeam of the suspended span. The stringers have a sliding connection on bracket seats on the end floorbeam of the suspended span.

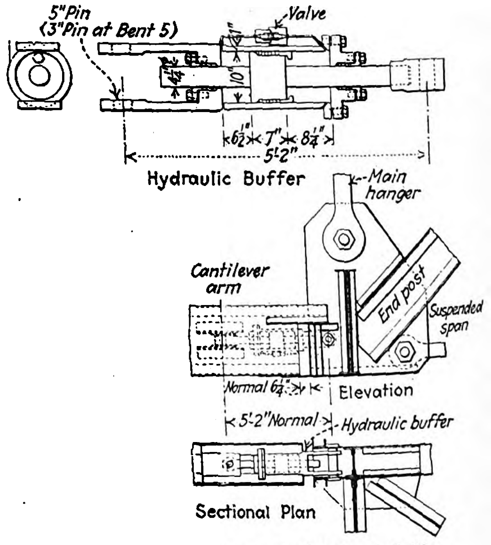
In the roadway, a special grid expansion joint was provided with strong bars of steel connected alternately to the two sides of the 11″ expansion joint. This joint permitted 5½″ reduction of distance, and 5½″ increase, making the total of 11″ expansion.

Expansion joints were also provided in the sidewalks, and in the railings.

To tie the two parts of the structure together in the event of an earthquake, hydraulic buffers were provided, fitted into the bottom chords across the expansion joints. In each hydraulic buffer, there is a piston free to work back and forth against the resistance of the fluid. The fluid displaced from one end of the cylinder passes by a check valve to the other end, and this check valve is so designed that, in case the piston has a movement imposed on it exceeding a velocity of 4/10 of an inch per second, the check valve will close and arrest the motion of the piston; and the specified force of 250,000 pounds will then be immediately developed across the gap. 4/10 of an inch per second is a comparatively small velocity. In the case of the 1906 disaster, the observed constants indicated a velocity of 11″ per second; the specified velocity of 4/10 inch per second is only 1/28th of the 1906 record. When such a small tremor or vibration takes place, the motion will be promptly arrested and the two parts of the structure will become tied together like a unit. There were six such hydraulic buffers, one at each corner of the suspended span expansion joints, and two between the main structure and viaduct at Tower 5.

In the cross section of the bridge, the trusses are 42 feet center to center, so as to provide a roadway of 30-feet clear width and two 4-ft. sidewalks. In the middle of the roadway, provision is made with special cross stringers for the possible addition of an electric railway track, the bridge being designed for that load in addition to the highway loading.

In addition to high curbs, the railing is of sufficiently substantial construction to resist a possible impact of a car which might jump the curb, and for that purpose we designed the railing to withstand a horizontal blow of 3,000 pounds at any post.



Arrangement of Hydraulic Buffer at End of Suspended Span

FIG. 13—HYDRAULIC BUFFER

The building of the approach highways was a large sized job. For the north approach a few hundred thousand yards of earth had to be moved from cuts 50 and 100 feet deep. All of the work was rushed to completion for the opening celebration on May 21st.

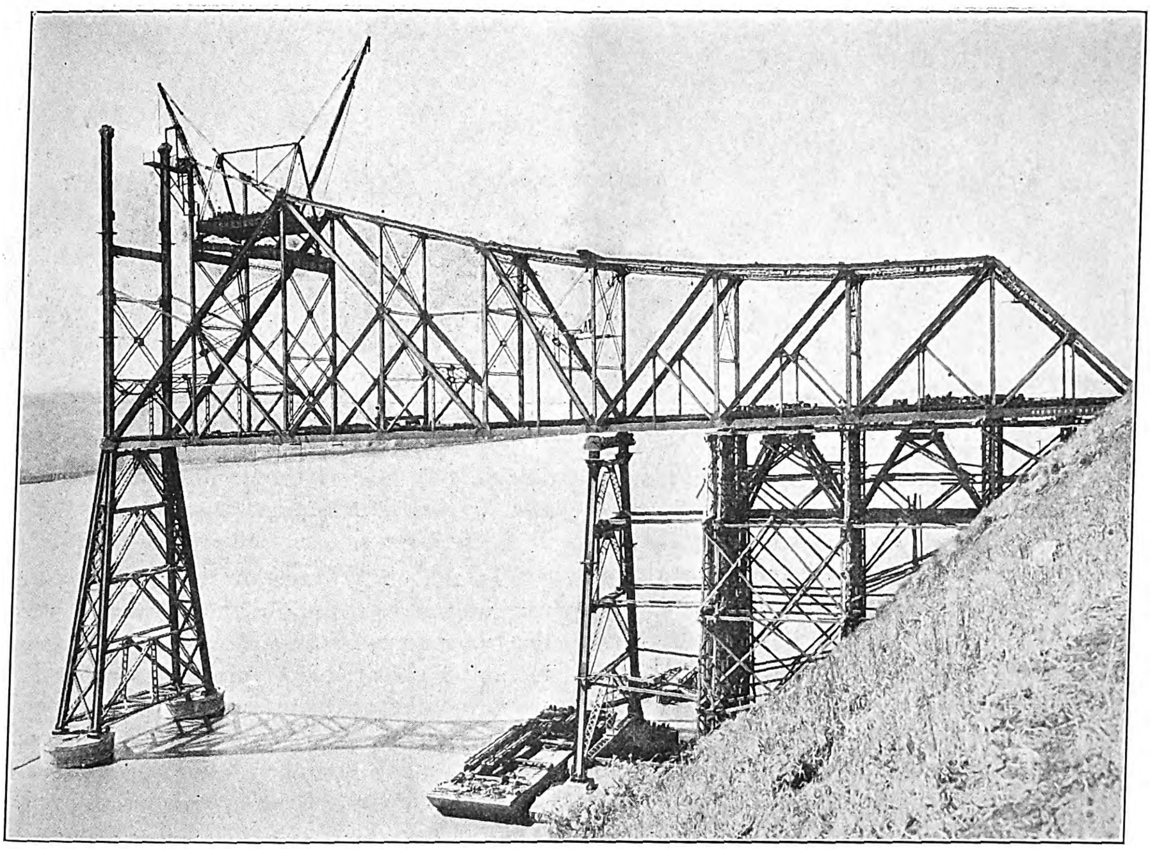


FIG. 14.—ERECTING SOUTH ANCHOR ARM

Erection

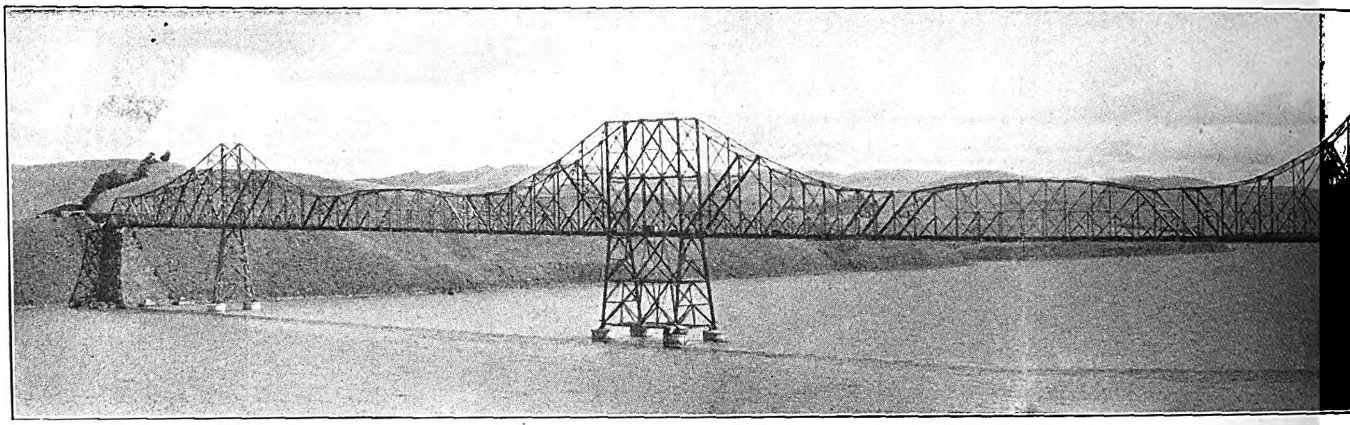
By C. F. GOODRICH

A MAP of California shows very plainly the reason for building the Carquinez Strait Bridge. The main valley of Central California drained by the Sacramento River in the north and the San Joaquin in the south runs north and south as do also the mountain ranges, the Sierra Nevada and the Coast Range. The important lanes of travel therefore naturally run in a north and south direction. But the valley is cut in two just north of San Francisco by San Pablo and Suisun Bays which interrupt the north and south travel lanes. These bays are separated by Carquinez Strait. Heretofore it has been necessary to cross by ferry in order to get into northern California or go around the bays and cross the river deltas near Sacramento. The Bridge affords a direct crossing for the north and south highway traffic.

After finishing the viaduct, falsework was erected for the support of the south anchor span. A million and a half feet board measure of Oregon fir lumber was used under this span. All timber placed in the water was creosoted to about 2″ penetration which proved a very effective barrier against teredos. We next placed the bottom chords, floor, and all truss members of the anchor span that could be reached and also tower No. 4. We used a traveler equipped with two booms, one at each forward corner.

The trusses of the cantilever and anchor arms were too high to be reached by a traveler on the bridge deck. The deck traveler therefore erected a top traveler on a track placed part way up in the trusses. These two steel top travelers, one for each side of the strait, were especially designed for this job and were equipped with two booms one at the front of 30 tons capacity and one in the rear for taking down the traveler track and filling in bracing, of 12 tons capacity. The traveler track was two panels long so that the traveler sitting in one panel could remove and replace the other panel of track. The traveler track had a grade of about 17% upward in the anchor spans and downward in the cantilever spans.

After the last members had been placed the south anchor span was closed to form a simple span by jacking on the falsework bents until connection could be made. The falsework however was left in place for some time in order to minimize movements. At the peak of the traveler track over tower No. 4 it was necessary to lengthen the front legs and shorten the rear legs of the traveler in order to accommodate it to the down grade in the cantilever span. This was done by rigging a block and tackle to the top of the main tower and lifting, first the front end and then the rear end of the traveler and the lengths of the legs changed. The top traveler was moved on its track by means of its own power.



The Carquinez Stra

Dr. Steinman mentioned that the main tension members were built of heat treated eye bars. Twenty-eight (28) bars were selected representing the various sizes used in the structure from a maximum size of 14″x$1\frac{15}{16}$″ to a minimum of 8″x1″ and tested to destruction. The results of these tests are given in the following table. It was specified that the bars should have a minimum elastic limit of 50,000 pounds per square inch, a minimum ultimate strength of 80,000 pounds per square inch and a minimum elongation of 8% in 18 ft. You will note that there were no failures among the 28 tests and that the averages were considerably above the requirements. A designing unit stress of 24,000 pounds per square inch was used for these bars.

Physical Properties of Full-Sized Test Eye-Bars Carquinez Strait Bridge

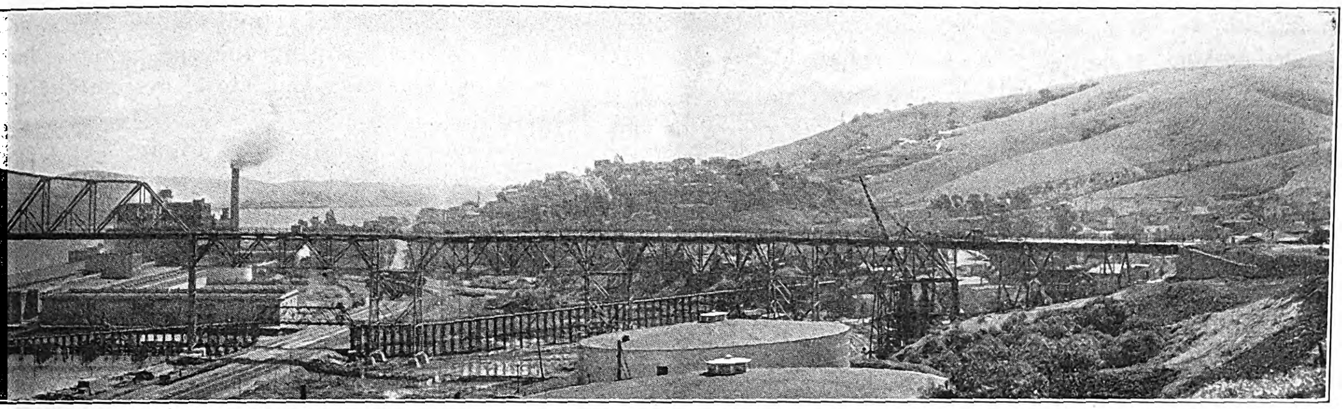
No.	Nominal section in inches	Length Feet	Elastic limit, in pounds per square inch	Ultimate strength, in pounds, per square inch	Percentage of elongation, in 18 ft.
1	14x$1\frac{15}{16}$	37.5	54 640	82 600	14.1
2	14x$1\frac{15}{16}$	37.5	55 680	85 350	11.3
3	12x$1\frac{7}{8}$	40.0	58 600	89 790	11.7
4	12x$1\frac{7}{8}$	40.0	55 880	86 180	11.2
5	12x$1\frac{13}{16}$	40.0	54 850	85 000	13.5
6	12x$1\frac{3}{4}$	40.0	55 060	82 590	13.3
7	12x$1\frac{9}{16}$	35.0	55 180	83 150	14.7
8	12x$1\frac{9}{16}$	40.0	61 480	91 940	9.6
9	12x$1\frac{1}{2}$	35.0	60 580	91 020	8.1
10	12x$1\frac{1}{2}$	35.0	58 260	84 950	11.2
11	12x$1\frac{1}{2}$	35.0	65 940	96 150	10.1
12	12x$1\frac{1}{2}$	40.0	54 660	82 970	11.3
13	12x$1\frac{1}{2}$	40.0	60 660	90 990	11.8
14	12x$1\frac{1}{2}$	40.0	52 510	80 270	11.6
15	12x$1\frac{1}{2}$	40.0	56 600	86 980	11.8
16	10x$1\frac{11}{16}$	40.0	59 230	89 450	11.9
17	10x$1\frac{11}{16}$	40.0	56 700	85 610	11.6
18	10x$1\frac{5}{8}$	40.0	59 940	86 360	11.3
19	10x$1\frac{5}{8}$	40.0	57 670	85 570	9.4
20	10x$1\frac{3}{8}$	40.0	59 470	88 310	12.2
21	10x$1\frac{3}{8}$	40.0	58 230	83 500	11.0
22	8x2	35.0	56 820	85 860	9.7
23	8x$1\frac{13}{16}$	40.0	62 670	92 620	9.0
24	8x$1\frac{9}{16}$	40.5	60 480	89 520	11.8
25	8x$1\frac{3}{8}$	41.0	58 690	85 540	11.8
26	8x$1\frac{5}{16}$	29.5	58 090	85 710	11.7
27	8x$1\frac{5}{16}$	31.0	63 450	92 080	9.3
28	8x$1\frac{5}{16}$	31.0	59 780	91 120	9.8
Average................			58 280	87 190	11.3
Minimum requirements....			50 000	80 000	8.0

In the early stage of the manufacture of these bars we had to maintain considerable secrecy in order that we might be free from interference in the perfection of the art of producing these bars. However, we now feel that the art has been so far perfected that it is no longer necessary to maintain any secrecy, and the customer's engineers and inspectors are now allowed to view all of the operations of production.

On the north side the water around pier No. 2 was 90 feet deep prohibiting the use of falsework. We were, however, able to obtain the use of a large United States Navy floating crane from the Mare Island Navy Yard. This crane is a huge affair costing a million dollars and having a capacity of main falls of 150 tons and a vertical reach above the water of 168 feet. Handled by ocean going tugs, it served us admirably.

The north anchor span had to be erected partly over the shore on a very steep bank and partly over water 90 feet in depth. Falsework was used on the bank, and at the shore line, on temporary piers, a bent from tower No. 3 was placed in temporary position. (See Figure 14.) About this bent, the portion of the north anchor span over the water, was cantilevered to tower No. 2. The span was ereced higher than its final position in order to provide clearance at tower No. 2 and also about six inches north of its final position for the same reason. The top of this bent was equipped with segmental rollers for moving the span forward and pin shoes to allow rotation. The reaction on each of the columns of this bent was about 4,000,000 pounds, and the uplift at the shore end of the span about 430,000 pounds per truss, one-half of which was taken by means of temporary eyebar links down to the anchorage in the abutment and the other half by counterweight in the form of earth placed on the deck in the rear panels.

The operation of closure of this span and connecting it to tower No. 2 was as follows: Hydraulic jacks (see Figure 6) at the shore end were allowed to run



Total length 4482 feet

out thus releasing the uplift and allowing the span to rotate vertically about the temporary pier and at the same time jacking the span forward toward tower No. 2 until the closure pins and bolts could be driven. The shore end of the span was then further raised by hydraulic jacks under the end floor beam until the shoes on the temporary bent could be removed. The shore end was then lowered by the same jacks to its final and permanent position. The reaction at the shore end for this last jacking operation was 650,000 pounds per truss, and the total vertical movement 32 inches. There were no accidents or trouble of any sort during this rather complicated operation.

By the 8th of February, 1927, all the steel in the structure except the two suspended spans had been placed and there remained the preparation for and the actual raising the suspended spans. The preparation of the adjacent cantilever arms for raising a span was as follows. From the mid point of each end diagonal was hung by means of a temporary link a counterweight box which was filled with sand hoisted up from sand barges below. To the top of this counterweight box were attached two 2½-inch steel wire rope cables which were passed up over two 5-foot cast steel sheaves directly over the box along the diagonal to its upper end, over two more 5-foot sheaves and

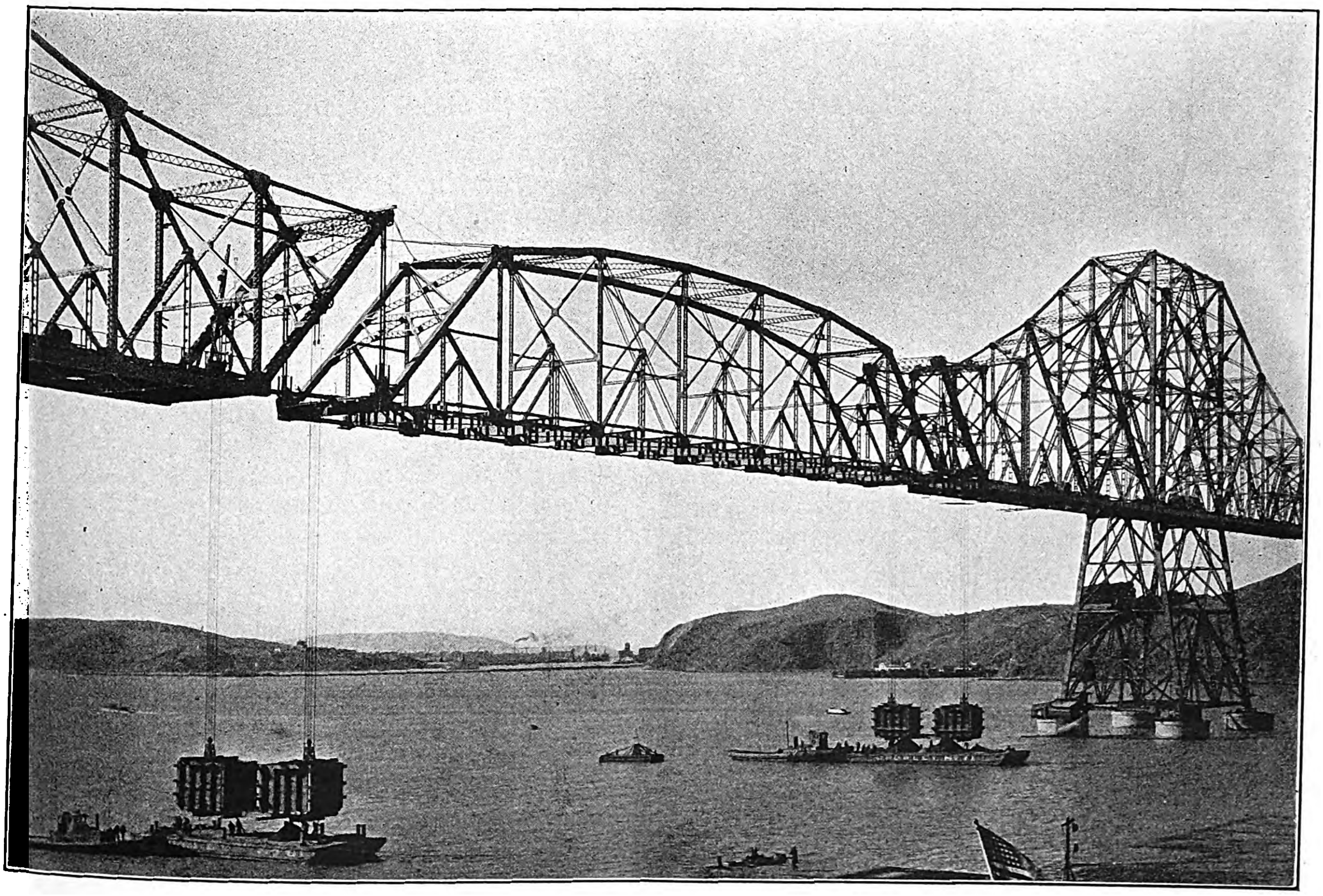


FIG. 15—REMOVING SAND FROM COUNTERWEIGHT BOXES

hung down nearly to water level with sockets attached to their ends ready to be attached to the suspended span. An eight part ¾-inch wire rope block and tackle was rigged to each counterweight box and its lead line passed back through snatch blocks to an electric hoist on the cantilever arm.

On the morning of March 3rd at about low tide the first suspended span was jacked from the dock onto two 40 ft. by 130 ft. steel barges and floated to position under the cantilever arms and the counterweight cables attached to it. The weight of the span about 650 tons was transferred by means of hydraulic jacks from the barges to the cables, this operation taking place during ebb tide. The weight of the span was therefore balanced by the weight of the counterweight boxes of sand and a little more as each box weighed about 22 tons more than one corner of the span. This extra weight was lifted by the eight part block and tackle and the hoisting engine and the temporary link removed. The counterweight boxes were then lowered simultaneously, their extra weight being enough to overcome friction and other resistances. This operation was controlled from one point of a cantilever arm through an open telephone system to the various points of action. Instrument men were posted at two points on the towers who reported levels of the rising span to the control man. The span was leveled up occasionally during the raising in order to keep from overstraining the lateral system due to excessive working.

Manilla rope cross falls (see Figure 11) were rigged up to the hip points of the suspended span and controlled by the nigger heads of the hoisting engines which could exert an extra lift on the span in case the counterweight boxes were not heavy enough. These falls were not called into use however during the lifting but served as a lateral system between the suspended span and the cantilever arms until the regular laterals could be placed.

The total operation, from the time work was started at the dock preparing the span for floating, until the span was in place and the counterweight boxes emptied of sand and removed, occupied a full day but the actual time of lifting the span from the barges to its place in the structure was only 35 minutes as compared with two days required for the lifting of the Quebec suspended span.

On March 19th the second suspended span was floated and raised thus linking the whole structure from end to end. There were no accidents of any kind during these rather hazardous operations and everything worked out entirely on schedule and according to calculations.

Hardened Copper*

A Recovered Art

THERE exists on the part of those not intimately connected with the working of copper, a belief that the ancients had a method of hardening that metal, with which art we today are not familiar. The fact of the matter is that our present-day metallurgists not only understand how the ancients hardened their copper and bronze, but also know how to produce copper and bronze products that are even harder than those left to us and which represent the evidence of the so-called lost art of hardening copper.

Cutting edges developed on swords, daggers, knives and other implements by the ancients were obtained by hammering the metal, or, in other words, cold-working. Those old metal-workers not only hand hammered their copper implements but also used the same means to harden their bronze articles. The heating of many of these products in open fires resulted in the formation of considerable copper oxide, which alloyed with the copper and hardened it. One of the most common mistakes of persons claiming to have rediscovered "the lost art of hardening copper" is to heat it in a forge and in this way saturate it with copper oxide, which combines with the copper to form a much harder and much more brittle product.

There are really two methods of hardening copper that are regularly practised nowadays, just as centuries ago. One consists in alloying the copper with some other metal or several other metals such as zinc, tin, nickel, cadmium, chromium, cobalt, silicon, aluminum, iron, beryllium and arsenic. The second method consists in cold-working the metal or copper alloy. In fact, it is possible to work the metal to such a stage of hardness that a slight amount of additional work will cause it to break. The explanation of all copper hardening may be attributed to one of these methods or a combination of them.

Microphotographs of an ancient copper spearhead indicated that it was extremely hard and that apparently this hardness had been obtained by cold working.

Copper scissors, knives and other cutting tools may be obtained. Unless, however, a special reason exists for their use, they offer no advantages over tools made from steel. Occasionally, however, it becomes necessary to use copper or bronze tools, such as knives. Around a powder plant, for instance, where all sparks must be avoided, bronze knives are almost essential.

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*Engineering Foundation Research Narrative No. 128. Contributed by William G. Schneider, Copper and Brass Research Association, New York.

The actual hardness of annealed commercial copper as determined by the Brinell machine is from 40 to 50. The hardness of cold-worked pure copper probably does not ever exceed 120 Brinell. The hardness of copper that has been alloyed with some other metal, or a number of metals, rarely exceeds 250 Brinell, although a hardness just over 300 has been attained as an upper limit. As a basis of comparison for readers unfamiliar with measuremnets of the hardness of metals, it may be stated that the Brinell hardness of very "soft" iron is around 80 and of steel used in common cutlery, such as in a finished pocket knife, about 420 Brinell.

Not only do many persons spend a short while endeavoring to rediscover an art that never was lost, but some of them devote a whole lifetime to this effort. The tragedy, or rather, the denouement, occurs when they have evolved a hard copper. They next endeavor to find some use for it and then learn that, unless it has some special properties, no market exists. Copper wire, hard drawn, has a tensile strength of about 65,000 pounds per square inch and an elongation in 10 inches of about one per cent, with a conductivity of about 97 per cent. This affords some basis on which to work when endeavoring to develop the hardening of copper. If, for example, it were possible to harden copper so that the tensile strength were materially increased above that just stated, without reducing the conductivity, a worthwhile discovery would have been made.

Some recent methods of hardening copper by alloying have, to a certain extent, come about as near to actually "tempering" copper as would seem possible. In these methods the metal, silicon, plays a most important part because it forms silicides with other metals which in turn form eutectics with the copper. The deoxidizing effect that silicon by itself exerts plays no unimportant part in finally allowing the metal to be worked and by heat treatment to develop a high strength, with a relatively high conductivity. This latter, however, is considerably below that of pure copper and second only, speaking of alloys from the standpoint of both strength and conductivity, to those of copper and cadmium. Alloys of copper with cadmium give, for a stated conductivity, higher strengths than those with silicon.

Items of Interest

Highways of the United States

More than a billion and a half dollars was spent in the United States for road building and maintenance during the fiscal year, June, 1924-1925, according to a study just completed by the National Industrial Conference Board. Whereas less than 20 years ago expenditures for road building were a negligible item in governmental finance. Our present annual road bill amounts to more than one-sixth of the entire public budget, and is exceeded only by our governmental expenditures for education and protection.

Perhaps more striking than the increase in total mileage of roadways is the change in the character of the new roads, influenced primarily by the automobile traffic. Winding, often ungraded and rutted, albeit picturesque roads have been giving away rapidly to hard surfaced, wide and straight highways particularly during the past few years. While in 1904, only slightly over 7 per cent of the total roadway mileage was graded and surfaced, more than 17 per cent of the much increased total mileage was graded and surfaced in 1925.

The vast change in transportation methods and road utilization caused by long distance automobile traffic is strikingly reflected in the great stimulus given to highway construction in the more sparsely settled mountain and western states during the past few years. The more densely populated eastern states, already well supplied with roads, have concentrated more on improving existing roads, even abandoning many older roads made obsolete by the more systematically linked modern highway system demanded in this age of the automobile.

Sounds of Human Voice in Pittsburgh Turn on St. Louis Street Lights

The new street lighting system in St. Louis was put into operation by the sound impulses of the human voice carried by radio waves.

The voice of the Mayor of that city was sent to the Westinghouse radio station in Pittsburgh where it released the transmitting equipment that shot back short waves to St. Louis and put into operation the mechanism that turned on 10,000 street lights for the first time.

Among the unique features of the new system's equipment are hollow concrete light standards made by the centrifugal process whereby the concrete is poured into a mold and whirled or spun into shape, leaving the post hollow for placing the light cables within.

The substation controlling the lights is provided with an astronomical clock which regulates the time of turning the lighting system on and off. This is the first time such an application of lighting regulation has been made in the United States.

Airplanes Are Firefighter's Eyes

Airplanes play much the same role in the warfare against forest fires that they do in military tactics. They enable officers of the forest rangers to get a rapid bird's-eye view of large forest fires and to direct the attack accordingly—an extremely important thing, especially in mountainous country where the reconnaissance of large fires is arduous and slow when done on foot or horseback.

A number of Army planes will be used in the coming summer campaign against fire, helping to protect the National Forest of California and the Pacific Northwest. The planes will operate from bases at good strategic points near the forests and will be piloted by Army Air Service reserve officers temporarily in the employ of the Forest Service. Special flights will be made whenever an emergency arises, the pilots being accompanied by forest officers who will act as observers.

In cloudy or hazy weather and in regions where the atmosphere is heavy with smoke of forest fires so that the visibility of ground lookouts is greatly reduced, planes take up the work of patrol. Airplanes also are called for patrol duty after heavy electrical storms have occurred, as these often set a number of fires in widely separated parts of the forest.—E. F. T.

Increase in Production

The total manufacturing production in the United States has increased about 65 per cent in volume from 1914 to 1925, or at a rate about 3½ time as fast as the population, which has increased less than 18 per cent during the same period, according to a study just completed by the National Industrial Conference Board. The production of our manufacturing industries per wage earner employed in 1925 was 35 per cent, or more than a third greater than in 1914, volume of production having far outstripped the increase in the number of workers as well as population growth.

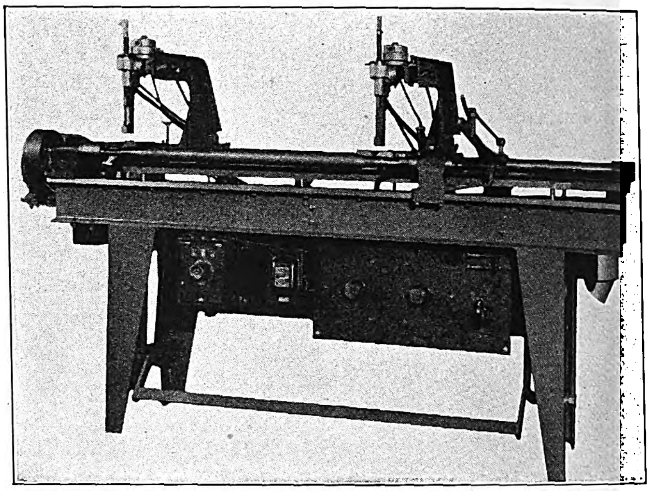
Production in the iron and steel industry in 1925 was 86 per cent greater than in 1914, and that of the chemical industries, 99 per cent or about double. Stone, clay and glass production during the same period increased only 57 per cent; the manufacture of food and food products, more closely following the rate of population increase, in 1925 exceeded that of 1914 by only 43 per cent.

The lumber industry shows a relative decline, its production in 1925 having been only 3 per cent greater than in 1914. Textile production definitely reflects a change in consumer habits; in this case the decreasing amount of clothing needed for the modern wardrobe, the total production of the textile industries in 1925 being only 23 per cent greater than in 1914, and somewhat less than it had been in 1923.

Higher Welding Speeds Possible with New Welder

Welding heavy plates automatically at approximately ten times the speed which can be obtained with the single-arc manually controlled process, is now possible with a new automatic arc welder. The new machine bears the designation Duo-Arc Automatic Welder and consists of a standard travel carriage on which are mounted two automatic welding heads, and two reels of electrode wire. With this equipment the operation is just as simple as that of the single arc travel carriages. One attendant can supervise the two welding arcs as easily as he can one arc.

The new welder is of particular value in butt welding heavy plates. This is accomplished by two electrodes working one behind the other simultaneously. Thus the necessarily large quantity of metal required to fill up the seam is deposited in practically one-half the amount of time which would be required for the travel of one electrode.



The ordinary method of depositing the required thickness of metal in welding heavy plates is to weld twice with a single electrode over the same seam.

By using two electrodes, welding simultaneously, the time required to repeat the welding with a single electrode is saved.

An electrode larger than ¼-inch in diameter is not commonly used for high grade work because the deposition of metal cannot be accurately controlled and it is inconvenient for operators to handle the large amounts of electrical energy necessary, concentrated in a single arc.

For welding half-inch plate, the seam is prepared by beveling to an angle of 30°, total opening. With 3/16-inch electrode and approximately 250 to 300 amperes in each arc, a speed of welding of from five to seven inches per minute may be obtained. Thus the speed of welding is approximately ten times that obtained with a single arc manually controlled and the resulting weld is of better quality because of the decreased chance of burning the weld.

Investigation of Motor Truck Operations

During the recent investigation of motor bus and truck operations by the Interstate Commerce Commission, the Association of Railway Executives appointed C. S. Duncan, economist of the organization, to attend all meetings and report developments. In his report, which he has just completed, Mr. Duncan discusses the motor truck in part, as follows:

"There can be little doubt from the evidence given that a very considerable part of the motor truck operation today is supplementary to rail service. This is true of all operations that have taken the place of the horse-drawn truck, or wagon, in getting commodities to the freight station and in carrying commodities from the freight station. On the other hand, there can be as little doubt that the increase in the amount of the motor truck traffic over and above the original horse-drawn truck or wagon traffic and the increased range and speed of motor truck operation have made the motor truck more of a competitor with rail lines than the earlier operation.

"The 2,500,000 motor trucks in operation today have an average hauling capacity of about one and one-fourth tons per unit, which makes a total carrying capacity of about 3,125,000 tons. This total number of transportation units, with this substantial total carrying capacity, is operating day and night throughout the country, partly in competition with and partly supplementary to rail service. . . .

Truck Routes Parallel Rails

"Both the motor truck operators and the shippers by motor truck who testified before the Commission took the position that motor truck operations were not really competitive with those of the steam carriers, but that the motor truck operated in the field of the short haul, where the railroads claimed their traffic was not remunerative, and served as extensions and supplementary service to the steam carriers, thus becoming feeders to the steam lines. The facts as developed showed that there are considerable operations by motor truck that cover the complete transportation from origin to point of consumption for certain types of commodities and in certain localities. It was also developed that the motor trucks, like the buses, operate over the improved highways which more often than not parallel the steam lines.

Trucks Can't Supplant Rail Lines.

"No one made any claim, as has been said, that motor trucks can now supplant rail lines as the essential and fundamental transportation facilities upon which the movement of the country's traffic must go. On the other hand, a real and immediate problem arises with regard to certain short haul and branch line railroads. Truck operations may now be threatening the very existence of such rail lines. Both operations may not be essential to the communities which they serve. Certainly it is a question for those communities to determine which type of transportation they will have.

"The large question is that, if the motor truck has become a permanent part of our national transportation system, how can the two different types of transportation facilities work together in such a way that the fundamental transportation system shall not be injured or destroyed?"

"Research Narratives"

"Research Narratives," issued monthly by the Engineering Foundation, joint research organization of the four major Engineering Societies, are snappy little tabloid reviews of progress, presented in popular style.

"Chemistry in the Desert," extracted from articles by Dr. John E. Teeple, Chemical Engineer, New York, is the subject of the May 1st issue (vol 7, No. 5) and describes the industrial development of potash production in recent years at Searles Lake, California.

This is a tale of how a sickly "war baby" became a lusty chemical industry. It took much scientific nursing and plenty of rich milk. Fundamental research, skillful engineering, sound business economics and loyal cooperation of chemists, engineers and business men would have won anywhere.

Potash is essential to agriculture and is useful in many other ways. Continental U. S. A. consumes each year about 250,000 tons of K_2O, of which over 90 per cent goes on to the land. War cut off our supply from Germany. War exigency multiplied the price. More than 120 plants were created to produce potash in various ways in several parts of the country. Two of them were at Searles Lake, in the Mohave Desert, California. In 1918, production from 123 plants attained the maximum of only 54,000 tons K_2O. In July, 1922, potash was on the "free" list of the tariff and only one plant was in commercial operation, one of those at Searles Lake, and it had produced only 3,000 tons during the last year. Here the adventurers had invested up to 1919 more than $6,000,000. But one stubborn chemist got a vision of an American plant producing potash and other chemicals, at a profit, in competition with the world, and "thereby hangs our tale."

Searles "Lake" is a bed of crystallized salts about 12 miles in area, 60 to 70 feet deep, permeated with brine, and fed by underground streams. In this "lake" are eight salts of sodium, potassium and boron, including some 36,000,000 tons of potassium chloride.

The stubborn chemist first got assurance that enough patient money would be forthcoming to carry through the researches and reorganization. Then he picked a few young men who liked work and responsibility and had the hardihood to work and live in the desert. He showed them his vision. The group became an organism, a living, growing, cooperating entity, made up of self-reliant, unafraid, resourceful individuals, disregarding personal comfort, 115 degrees in the shade, or 24 hours a day.

The stubborn chemist certifies to his readers that there are plenty of men who will work their heads off intelligently and accomplish marvels, if management will realize, and make them realize, the dignity and importance of their work, give them authority along with responsibility, free them from nagging, from gloom spreaders, from constant dictation, and ask only for final results in scientific achievements coupled with economic success. And pay checks must maintain an encouraging relation to work done.

Trona, for so the place was called after one of the salts in Searles Lake, was, in 1919, just a desert mining camp. The labor turnover was 500 per cent per year, an entire new force on the average every ten weeks. In 1926, turnover was normal. Trona is now a beautiful town of a thousand inhabitants, with tennis courts, golf links, swimming pool, steam heat, running water, electric lights, and the other comforts of American civilization, including afternoon tea and "bridge."

Now the American Potash and Chemical Corporation can produce in the 1919 buildings, nearly 400 tons daily of potassium chloride, borax and boric acid of very high grade, at prices below pre-war, with a profit. Instead of tradition, a loud voice and a strong arm, the plant is run on meters, thermometers, charts and accurate knowledge. Every minute a ton of salt must be washed free of liquor and discharged from the plant. Every minute 200,000 gallons of liquid pass through pumps, apparatus and miles of pipes. The annual freight bill is $2,500,000. Research goes on, seeking other profitable products from the raw materials and greater economy in all operations, from getting the brine into the plant to marketing and purchasing. Research, intelligently managed, pays.

Air Transport Safe and Reliable

Pilots of the Air Mail Service in day and night flying over the transcontinental route from New York to San Francisco made the remarkable record of 1,250,000 miles for each fatality in the service last year, according to a statement made by L. B. Seymour, chief engineer of the National Air Transport, at a recent meeting of the Cleveland section of the Society of Automotive Engineers. He also stated that airplanes operated by the National Air Transport between Chicago and Dallas, Texas, a distance of about 1,000 miles, had been flown nearly 700,000 miles without having caused the loss or damage of a single letter. No serious accident has occurred and no person has been injured. An average of only one forced landing due to mechanical trouble has occurred for each 8,500 miles flown. On the basis of the foregoing facts, the speaker said he believes that air transportation is much less dangerous than is ordinarily thought.

Existing airways in the United States are already extensive, he said, and the present mileage will be largely increased by new routes shortly to be put into operation to and from Atlanta. The first leg of the transcontinental route is from New York City through Cleveland to Chicago, and the final leg extends through Salt Lake City to San Francisco. An extension of this route from New York reaches to Boston. Another airway extends from Cleveland to Detroit and thence to Grand Rapids, Mich., and another connects Cleveland with Pittsburgh. From Cleveland a new route will extend to Atlanta, Ga. A contract has been let for an airway that will connect Atlanta with New York City through Washington and Philadelphia. The so-called Pelican route already connects New Orleans with the mouth of the Mississippi at Pilottown, La., and saves an entire business day in reaching ocean steamships. Separate airways connect Chicago with St. Paul and Minneapolis, St. Louis, and Dallas, Texas. From Denver another route connects with the transcontinental route, while Salt Lake City is connected by airway with Boise, Idaho, with San Francisco, and with Los Angeles. On the Pacific Coast an airway extends from Los Angeles through San Francisco to Seattle, and another short airway extends from Seattle to the Vancouver line for connection with steamships.

Mr. Seymour said that upward of 1000 miles of lighted airways have been equipped in the United States during the past year and he believes that night flying will soon be possible on other airways besides the one from New York to San Francisco and that this will facilitate the carrying of mail and stimulate the carrying of passengers and light-weight goods.

County Highway Officials' Association

The American Road Builders Association through its Director, Charles M. Upham, has completed the organization of a National Association of County Highway Officials. The need for such an organization has long been paramount in the United States. With 3,070 separate political sub-divisions constructing and maintaining highways without technical intercourse or standardization of methods, the waste of county or township funds has been inevitable. The expenditures under local agencies are approximately the same as those supervised by well organized state departments. The roads affected are in most cases thoroughfares of a peculiar nature, being all-important to the immediate district in which they are laid, but at the same time not handling sufficient traffic to justify the construction of the more expensive modern highway. This peculiarity makes the county problem of intricate importance, and emphasizes the necessity for technical standards of grading, graveling, surfacing or otherwise improving the local road. Through such an organization as Mr. Upham has brought into being, a great deal can be accomplished, both from the standpoints of efficiency and economy.

The Relation of Motor Fuel Characteristics to Engine Performance

The Department of Engineering Research, University of Michigan, has issued Bulletin No. 7, May, 1927, by George Granger Brown, on the above subject, 129 pages, illustrated. The author reports results of a thorough laboratory study of the relationship of engine performance to two important characteristics of the fuel, namely volatility and anti-knock qualities. Specifications for volatility for different temperature conditions are suggested that give practically uniform engine performance at all seasons of the year; also methods of supplying fuels of these characteristics at no increase in cost of production. The cause of engine knock was studied, specifications are given for a fuel of requisite anti-knock qualities, and methods suggested for obtaining such a fuel.

Large Springs in the United States

The Department of the Interior has issued a very interesting memorandum giving information about a number of large springs in the United States.

Among the larger springs in this country are those that issue from the black lava walls of the canyon of Snake River below Shoshone Falls, Idaho. In a 40-mile stretch of the canyon below the falls there are eleven springs of the first magnitude, the largest of which furnish about enough water to supply New York City, and altogether the springs that discharge into this canyon yield enough water to supply all the cities in the United States, of more than 100,000 inhabitants, with 120 gallons a day for each inhabitant. Unfortunately, however, not even one large city can avail itself of this abundance of spring water, which is as pure as any bottled water sold for general use. Many of the springs issue 100 to 200 feet above the river, and their clear waters, dashing over the black rocks of the canyon walls, produce cataracts of striking beauty. The Thousand Springs, which discharge 864 cubic feet a second, are now in part harnessed to produce power, but formerly they made a waterfall 2,000 feet long and 195 feet high. Snowbank Spring, which is a part of the Thousand Springs, dashed over the rough talus slope forming a cataract of pure white against a background of intense black.

The Business Situation

Col. Leonard P. Ayres in the Business Bulletin of the Cleveland Trust Company gives the following interesting review:

"STEADILY increasing competition in both industry and finance has characterized general business during the first half of 1927. The volume of industrial output has been large in most lines, and in many of them a little greater than current demand. As a result the general trend of commodity prices has been a declining one. As a consequence industrial and commercial competition has been keen, and it has been the experience of large numbers of manufacturers, and of perhaps most jobbers and wholesalers, that it required an exceptionally large volume of transactions to make even a moderate profit.

"Employers faced with these conditions have made some reductions in working forces, and this, combined with the declines in commodity prices, has operated to reduce the amount of money in circulation. Each month so far in 1927 the current needs of commerce, industry, and transportation have required decreasing amounts of money, and meanwhile large sums of gold have been sent here from abroad. The combined effect of these developments has been to increase largely the available credit supply, with the result that in this past half year we have had an unusual competition for employment by capital, as well as competition for markets by goods, and some competition for employment by workers.

"The competition of capital has been most evident in the security markets. On the stock exchange the volume of transactions has exceeded all previous records, despite the fact that an unusually active bull market had already been in progress for two and a half years when this year began. Moreover during the past six months the volume of new securities floated has been far greater than in any previous similar period. Another effect of the great credit supply has been to extend and expand the booms in building construction and real estate speculation that were thought to have already run their courses. The probabilities are that these conditions will continue without important change during the rest of this year. Business prospects are bright rather than brilliant.

Iron and Steel

"Production in the iron and steel industry has been almost as great in the first half of 1927 as it was in the first half of 1926, but it has been sharply curtailed during the past month. At the present time the output of the industry is smaller than it was a year ago, the prices of its products are lower, and its profit margins are narrower.

"The automotive industries are taking about 15 per cent less steel than they were a year ago, with little prospect that this condition will be materially changed in the coming six months. The railroads have ordered 40,500 new cars so far this year, which is almost exactly the same as the number ordered in the first six months of last year. Orders for track materials are holding up well.

"At the end of June there were 362 serviceable blast furnaces, of which 198, or 55 per cent, were in blast. This was a loss of 13 furnaces since the last of May, which is the largest monthly decline this year. The decline of 13 blast furnaces in June was the net result of the blowing in of one merchant furnace, and the blowing out of 14 steel works furnaces. It is apparent that steel producers acted decisively in June to bring steel production down so that it would not exceed demand."

The Guaranty Trust Company of New York writes as follows:

"FURTHER recession, apparently due for the most part to seasonal influences, has characterized business activity in recent weeks. Very few branches of production or distribution, however, show any sign of positive reaction. In basic industrial operations, in sales volumes at wholesale and retail, and in fundamental financial conditions, there is ample evidence to support the belief that business in general is on a sound basis.

"If any recent developments contain ground for misgivings, they are the continued advance in bank loans against security collateral and the rather dubious agricultural outlook. Crop prospects are, at worst, only a little more uncertain than usual, and the season may yet prove to be more satisfactory to the farm population than were those immediately preceding it.

Foreign Trade

"The country's foreign trade in May was smaller than in April, but exceeded any previous May totals in recent years.

"For the first eleven months of the fiscal year, exports amounted to $4,611,000,000, the largest total recorded since 1921; while imports, aggregating $3,899,000,000, exceed any comparable figure since 1920, with the single exception of that for last year. The export balance for the fiscal year to date, on the other hand, while much larger than that of a year ago, is smaller than for 1925 or 1924.

Financial Conditions Strong

"Gold imports last month were the largest since January, amounting to $34,212,000; while exports totaled only $1,510,000. Imports for the eleven months of the fiscal year amount to $237,135,000 and exports to only $101,003,000, leaving a net import balance of $136,132,000, the largest since 1924.

"Although there has been little change in the level of money rates during the last few weeks, the tendency has been toward greater ease, notwithstanding the large volume of new capital flotations and the new high record in the amount of brokers' borrowings in New York City.

Industries Report Seasonal Recession

"Steel mill operations have been less active in recent weeks, and are now somewhat smaller than a year ago. Pig iron output last month averaged 109,385 tons daily, as against 114,074 tons in April and 112,304 tons in May last year; while the average daily production of steel ingots amounted to 155,624 tons, which compares with 158,844 tons in the preceding month and 151,076 tons a year earlier. Unfilled orders reported by the United States Steel Corporation declined 405,191 tons during May, and on May 31 totaled only 3,050,941 tons, the lowest figure recorded in seventeen years.

"A similar trend is evident in building operations. New construction undertaken in May was in smaller volume than in April but was slightly larger than in May last year. As yet the building industry gives no indication of a marked recession in activity.

"Unusual irregularity prevails in automobile manufacture, due in part to the expected announcement of a new model by the leading producer of small cars. Operations of the industry as a whole are believed to be about 10 per cent below the level of a year ago, with the trend seasonally downward.

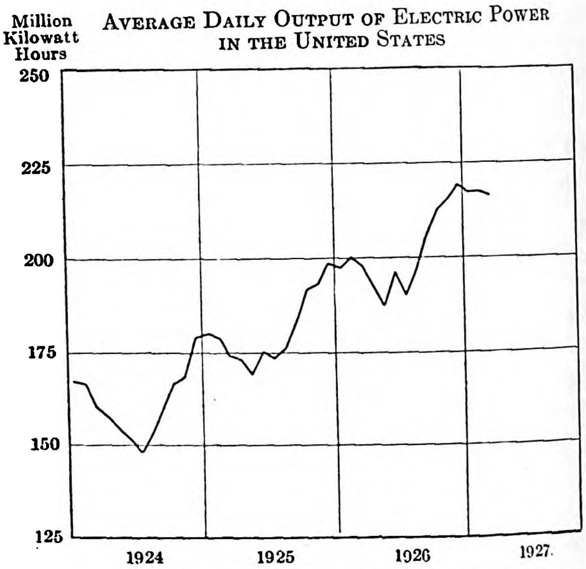
"Bituminous coal production continues at the rate of about 1,400,000 tons a day, which is somewhat below the current rate of consumption, but not enough so to occasion any serious concern. Consumers apparently remain indifferent to the possibility of a shortage in case the strike is prolonged beyond the general expectation.

"Crude oil production reached a new peak during the week ended June 18, averaging 2,509,650 barrels daily, as against 2,498,450 barrels in the preceding week and 2,011,600 barrels a year ago. The situation has not yet given any sign of response to the restrictive measures recently adopted. Output in the Seminole area, where producers have attempted to exert some measure of control, has continued to advance.

Electricity

"An examination of the trend of electric power production in the last few years reveals the influence of a number of factors. The most striking of these is a rapid and remarkably even rate of increase in the use of electricity for domestic and industrial purposes.

"The element of secular or long-term growth remains the outstanding characteristic of the industry, completely overshadowing whatever increase may be attributable to the improvement in general business conditions. The gain in electric power production has easily surpassed both the increase of population and the expansion of business activity. While the average rate of output by manufacturing industries, according to the Department of Commerce, increased by 28 per cent between 1919 and 1926, the rate of electric power production rose during the same period by more than 88 per cent.



Courtesy The Guaranty Trust Co., New York.

"Aside from the element of growth, perhaps the most clearly marked tendency in electrical output is the regularity of the seasonal variations. This tendency, as the accompanying chart shows, has been especially pronounced in the last few years. The winter peak, the spring decline, the comparatively low level of output during the summer and the rapid advance in the latter part of the year are probably in part a reflection of the usual changes in industrial activity, but more largely due to variations in the use of electricity for lighting and domestic purposes.

"The progress of public utility operation has not been confined to an increase in the volume of output. The quality of service rendered has been vastly improved, while rates have been progressively reduced. Electricity is one of the few things that are cheaper today than before the war. In some cases lower rates have resulted from more stringent regulation, but by far the most important factor in rate reduction has been the decline in operating costs due in part to increased volume of output and in part to more efficient methods of production and distribution.

"On the basis of recent experience, it appears safe to say that very few industries, either in this country or abroad, have prospects of growth to compare with those of electric power production."

American Society of Mechanical Engineers Standards, Reports & Codes

Engineers in every important industry in the United States and in many countries of Europe have occasion to use A. S. M. E. Standards.

ENGINEERS AND ENGINEERING have arranged to carry copies in stock and can furnish promptly any of the following publications on receipt of price.

BOILER CONSTRUCTION CODES

1. **1924 Boiler Code.** Two hundred pages, illustrated. $2.50 postpaid.

For designers, manufacturers, inspectors and users of boilers. This widely-used book represents the latest information available on steam boiler practice throughout the United States. It is the authoritative source for such information as: Selection of materials, ultimate strength of materials used, maximum allowable working pressures, minimum thickness of plates and tubes, design and construction of joints, bracing and staying, furnace construction, riveting, materials specifications, inspection and stamping, safety valve requirements, rules for inspection and tests, etc.

2. **Suggested Rules for Care of Power Boilers.** Price $1.35.

For engineers, operators of steam boiler plants and all others engaged in the boiler industry. This Code gives practical suggestions on putting boilers in service, handling boilers in and out of service, operating and maintaining boiler applances, feed water analysis and treatment, etc.

3. **Rules for the Construction of Boilers for Locomotives.** Price 50c.

This Code deals with the chemical and physical properties of locomotive practice and includes the necessary formulas and methods of construction in detailed specification form for manufacturing safe boilers.

4. **Rules for the Construction of Low-Pressure Heating Boilers.** Price 80c.

In order to provide for the divergent classes of heating boiler construction, this Code is divided into two separate sections for Low-Pressure Steel Plate and Cast Iron Boilers with the steel plate section embracing an important innovation in the form of special rules for the construction of low-pressure boilers with welded joints.

5 **Rules for the Construction of Miniature Boilers.** Price 35c. (To members 25c.)

A Code which embraces special rules for boilers of small sizes.

6. **Rules for the Construction of Unfired Pressure Vessels.** Price $1.00.

The importance of this Code to the industry cannot be over-estimated. It was developed with a view to providing safe construction rules for the great variety of pressure containers now manufactured and used for innumerable purposes throughout the country and under an exceedingly wide range of conditions. In addition to the construction rules for Unfired Pressure Vessels, the Code also contains rules for the fusion process of welding, forge welding and brazing, as well as specifications for steel plate of flange quality for forge welding, and specifications for steel plate brazing.

STANDARDS AND REPORTS

1. **Safety Code for Elevators.** Price 60c.

This Safety Code which includes rules for construction, inspection, maintenance and operation of elevators, dumbwaiters and escalators is sponsored by the United States Bureau of Standards, the American Institute of Architects and the A. S. M. E. The present edition, approved as an "American Standard" in 1925, is a thorough revision of the Safety Code of 1921 and is intended as a guide to State and Municipal authorities, as well as a standard reference of safety requirements for the use of elevator manufacturers, architects and consulting engineers.

2. **Tolerances, Allowances and Gages for Metal Fits.** Price 50c.

The report covers the fundamentals for gaging of plain-parallel and cylindrical surfaces. It also gives definitions of terms employed in describing this practice as well as descriptions of the classification of fittings adopted by the Committee.

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Two series of screw threads are standardized upon in the report—an "American Coarse Series" for general work and an "American Fine Series" for work in which a finer thread is desirable. Different classes of fits (loose, free, medium and close) are established, as well as a standard screw thread nomenclature, and a system of identification symbols for use in correspondence, drawing and shop practice.

4. **Shafting Report.** Price 20c.

Prepared by the Sectional Committee on the Standardization of Shafting, this report recommends just fourteen sizes of transmission shafting and large reductions in the number of sizes for machinery shaftings.

5. **Square and Flat Stock Keys.** Price 20c.

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7. **The National Fire Hose Coupling Screw Threads.** Price 25c.

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8. **Spur Gear Tooth Form.** Price 35c, (to members, 30c).

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Allowing for the English viewpoint, this book appears to be one that no American oil man can afford to ignore.

R. H. K.

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Standard Construction Methods—By G. Underwood, Construction Engineer. 408 pages 6x9. Flexible Keratol; 330 illustrations. $5.00.

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On the basis of many years' experience in underground electrical work and as vice-chairman of the N. E. L. A. Underground Systems Committee, the author has written this thorough and complete treatment of all phases of underground electrical systems for engineers and constructive foremen.

Business Cycles and Business Measurements—By Carl Snyder. Cloth. $6.00.

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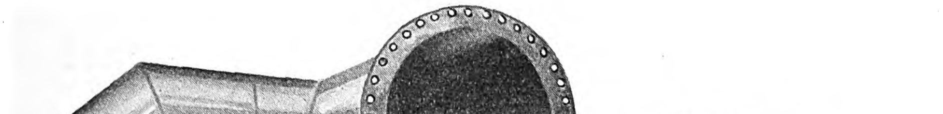
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ENGINEERS & ENGINEERING

AUGUST, 1927

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Oil-Electric Locomotives Win Favor With Chicago & North Western Railway*

By C. H. VIVIAN

THE rapid growth of our cities has given rise to numerous intricate and vexatious problems; and of these the railroads have been obliged to face their share. Rail transportation, so vital to municipal well-being and progress, has added to the congestion until relief is imperative.

When our larger urban communities were in the village or town stage, life revolved to a considerable degree around the railroad terminals, and it was but natural that they soon became hemmed in on all sides and that trains should, of necessity, cross numerous thoroughfares in entering or leaving the communities. At first this circumstance was of little moment; there was little traffic and even that was slow moving. Trains were infrequent, and a relatively small volume of freight was handled within corporate limits.

As the communities became sizeable cities, the railroad problem became a pressing one. It was a comparatively easy matter, although often an expensive one, to alleviate the passenger traffic phase of it. The tracks were merely elevated or lowered, removing them from the level of foot and vehicular traffic, and greatly speeding up the movement of trains into and out of terminals.

When it came to tracks used exclusively for freight handling, however, the grade separation method of solution was not always so easily worked out. Mercantile and industrial establishments had congregated along the trackage lanes to avail themselves of shipping facilities, and, as they had arranged their loading and unloading structures for the track levels then existing, it was hardly feasible to raise or lower rails. As an alternative, one method of procedure widely adopted was that of leaving the tracks as they were and bridging them at street crossings with viaducts. Even then the problem was not completely solved, for it was essential that track-level crossings be maintained for wagons and trucks bearing goods to and from cars and buildings having track frontage.

As the cities continued to grow and the skyscraper type of architecture came into being, a new complication arose. Oftentimes office buildings were reared adjacent to these trackage zones, and the frequent movement of steam-operated trains, with their noise and smoke, brought irritation to many of the tenants. About that time, also, cities began to develop an aesthetic sense and to revolt against the prevalence of soot. A great hue and cry arose in condemnation of every smokestack and, in spite of its aid to the public, the locomotive was branded as one of the culprits.

The railroads have been as anxious as the populace at large to see the problem solved. The movement of trains and the assembly and distribution of cars within cities has become increasingly difficult and, consequently, increasingly expensive. Accordingly, the interests of the municipalities and the railroads are on a common plane; and the carriers have been eager to discover a satisfactory way out of the complex situation.

Having thus outlined a condition that today confronts many cities and the railroads that serve them, it is interesting to direct attention to a specific instance in Chicago in which the railroad concerned has not only improved conditions, but has done so at a material monetary saving to itself.

What is commonlly known as the State Street and North Pier yard of the Chicago and North Western Railway Company is a section of great congestion. A two-track line extends for a distance of 1¾ miles along a street that parallels the nearby Chicago River. At frequent intervals along the course of the yard, warehouses, manufacturing establishments, and other industrial and mercantile structures rise at the sides of the tracks. An almost continuous line of them exists on one side. Among them are buildings housing concerns of importance in the business world.

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*Further information will be furnished promptly if inquiries are addressed to ENGINEERS AND ENGINEERING.

At various points, one or more tracks branch out from the two-track system to serve these establishments. In places a veritable maze of trackage exists. The system crosses numerous busy streets, including Michigan avenue. The general traffic of these thoroughfares is carried overhead, but entryways are provided at the track level to permit trucks and teams access to cars and to the buildings fronting the tracks. The switching of cars within such a zone is fraught with difficulties. Because of the crossings and the traffic in the street, a constant watch must be kept to avoid accidents.

After making a study of the situation, the Chicago & North Western officials determined to try out some other form of locomotive than the familiar steam type and, in May, 1926, a 60-ton oil-electric locomotive began operations. Improved conditions were so immediately evident that another unit was placed in service in October, 1926; and in April, 1927, a third was added. This type of locomotive now handles all the switching in the State Street and North Pier yard.

The substitution of oil-electrics for steam motive power units has effected a saving of approximately 50 per cent in operating costs. Specific figures of comparison are not yet available because insufficient time has elapsed to arrive at the maintenance costs on the new locomotives.

Some of the savings and advantages of the oil electrics were outlined as follows by George Hand, assistant to the president of the Chicago and North Western Railway Company:

"We found in our investigations that the locomotives in this service were running only 40 per cent of the time and were accordingly standing idle the remaining 60 per cent:. With steam locomotives in use, steam had to be maintained all the time and coal was being burned when the engine was motionless. In the case of the oil-electrics, the oil engine idles when power is not being used and the cost of fuel consumed is negligible.

"The steam locomotives worked two shifts of 12 hours each. After each shift they were taken four miles to a roundhouse. The oil-electrics are in service the full 24 hours, the three new units having replaced six steam units. This has resulted in the elimination of some roundhouse charges and also of some shop service and hostling charges. There has also been a small saving in wages paid engineers. The wage contract is based on the locomotive's weight on the drivers, the scale being lower for a locomotive under 70 tons than for one above 70 tons. The steam engines which were replaced weighed 73 tons each.

"It is obvious, of course, that there is less wear and tear on the tracks and roadbeds from lighter locomotives.

"As the fuel oil is automatically introduced to the engines, the duties of firemen have been largely removed. A fireman can now keep a constant watch for signals and for traffic on his side of the tracks, and materially assist the engineer in avoiding accidents and in speeding up switching operations."

To the foregoing observations there might be added others revealing benefits to the city. There is a gratifying absence of disturbing noises from puffing, exhausting steam, etc. Because of their swivel trucks, the oil-electrics round sharp curves silently, in contrast to the highly audible screeching set up by the steam-powered units.

There is no smoke, thus making for greater personal comfort of those in the vicinity. Inasmuch as Chicago's finest and busiest street, Michigan avenue, spans the yard, thousands of persons have cause, in the course of a day's traffic, to give thanks for the clearing of the atmosphere. During recent years, some of the city's largest and finest business buildings have been constructed in the section bordering upon this yard, and the removal of the smoke nuisance is doing much toward the preservation of their exterior beauty.

All three of the new locomotives are on duty continuously during six days of the week. On Sundays, one suffices for the switching, and the two others are given a routine inspection that day. Every three months, each is given a thorough inspection. No overhauling has been found necessary as yet.

Power from a 300-h.p. oil engine drives a generator which supplies current to motors mounted on the trucks and geared to the driving axles. The oil engine is of the 6-cylinder, vertical type. The fuel is fed to the cylinders by the solid injection method, and the prime mover is designed to make attainable in a notably high degree the efficiencies and economies which have been found possible with internal combustion engines using inexpensive oil for fuel.

The generator is direct-connected to the oil engine. It produces 200 kilowatts of direct current at 600 volts. Four 100-h.p. motors utilize the current, and these are mounted at points directly above the four driving axles.

Aeronautical Power Plants

By LIEUT. COM. R. S. HEDTLER, U. S. N. R.
Aeronautical Engineer, Naval Aircraft Factory.

At the Naval Aircraft Factory experimental work of the Bureau of Aeronautics is carried on, all detail design work and the building and testing of experimental naval planes before the issue of the contracts to civilian plants for production. At the Naval Aircraft Factory is the most complete aeronautical engine laboratory and every type of engine and appliance for Naval aeronautic use is given exhaustive tests to determine probable reliability in service and to develop possible changes in design of parts to increase the comparative reliability.

THE recent performances of Lindbergh, Chamberlin, Byrd and Maitland have again demonstrated America's superiority in the air, and have advanced the art of flying to a point where it has become an engineering science. As the development of the automobile created a demand for automotive engineers, so the future development of the airplane will create a demand for aeronautical engineers. With this axiomatic truth in mind a consideration of the problems of design, requirements, future trend and present situation will be of value to the prospective aeronautical engineer.

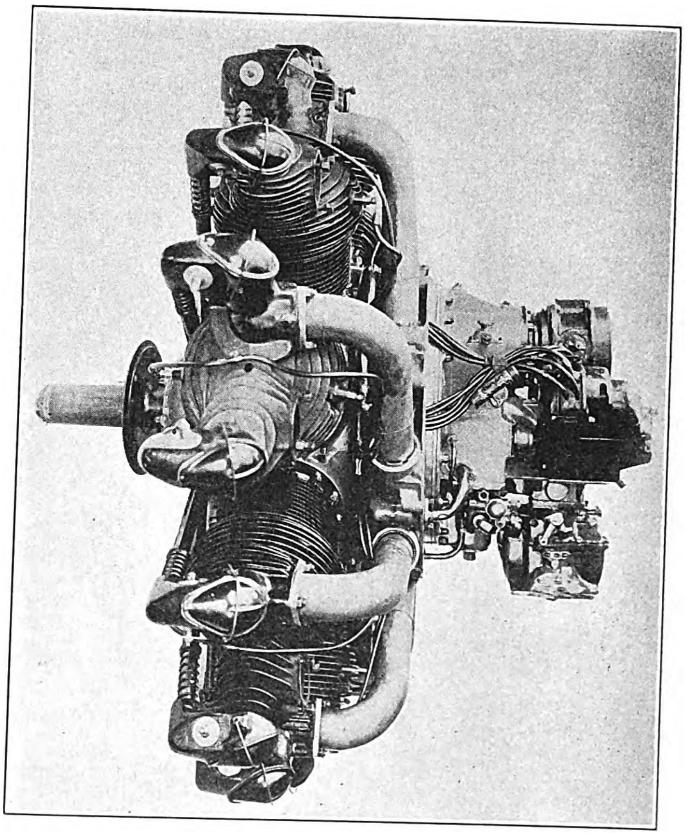
The features of an aeronautical engine as a prime mover being that it is solely designed for use in aircraft the design must be carried out to meet aeronautical conditions, not only from a weight viewpoint but from the reliability viewpoint as well. Absolute reliability is not obtainable; comparative reliability is all that we can rely on and may be defined as ablity to complete a predetermined task without faltering.

Among the essential features of all successful aeroplanes are the following:

Ability to ascend rapidly is of paramount importance in warfare where a machine's capabilities of evading destruction depend to a large extent on how quickly it can get out of range of projectiles. It must also be efficient in climbing in order to rise successfully from a small field or enclosed bay, as might be necessitated by a forced landing during a scouting flight. The rate of climb varies directly as the power developed and indirectly as the weight to be lifted, so climbing ability depends to a large extent on the weight efficiency of the engine.

A combination of fast and slow flying speeds is highly desirable, but this is only possible by the adoption of an extremely light and powerful engine. If the machine is designed for very high speed, a slow stalling speed is only possible by the aggregate weight being very light.

Safeness of handling in winds with or without engine in operation, is more characteristic of lightly loaded machines. Aeroplanes have been built that will carry as much as 15 to 20 pounds per square foot of supporting surface, but the average loading of the planes today is in the neighborhood of 7 or 8 pounds per square foot. A heavily loaded machine depends to a great extent on high speed of flight in order to maintain it in the air, and should the speed fall the control becomes sluggish and will not answer quickly, and only by nosing down promptly to increase the speed can the pilot prevent floundering. The life of the pilot and passengers in a heavily loaded plane is more dependent upon the good behavior of the engine than is the life of the pilot and passengers in a lightly loaded plane, and the latter could probably go on flying in search of a good landing place with two or three cylinders not firing at all.

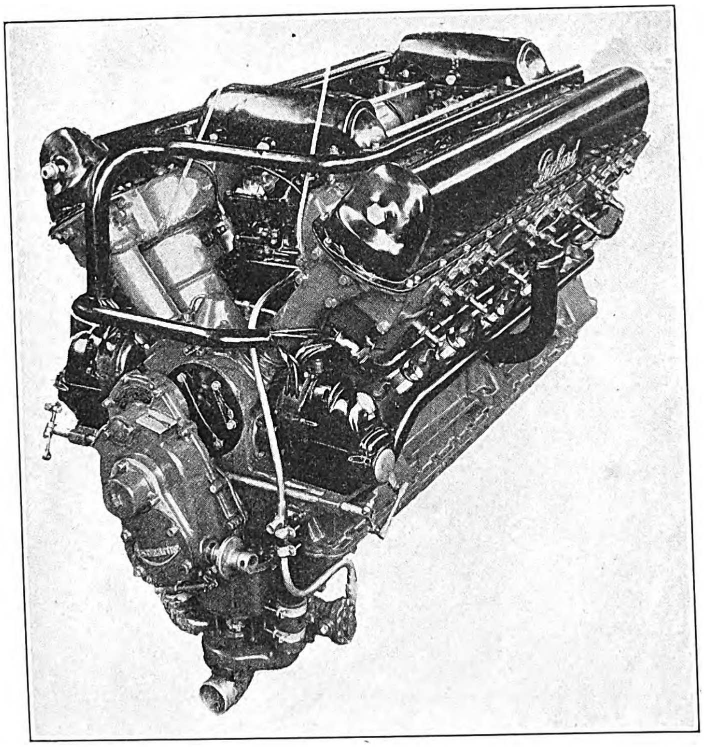


THE PRATT AND WHITNEY "WASP" NINE CYLINDER RADIAL AIR COOLED ENGINE OF 430 H.P. AT 1900 R.P.M., 1344 CUBIC INCH DISPLACEMENT, WEIGHT 650 LBS. THIS ENGINE HOLDS FIVE WORLD'S RECORDS AND HAS RUN OVER FOUR HUNDRED HOURS WITHOUT OVERHAUL.

Ability to remain in the air for long periods depends chiefly on the oil and gasoline consumption of the engine, and without efficiency in this respect the extremely light power plant is practically useless, as flights of short duration are not likely to be of much use in either commercial or military flying. Therefore, the three principal requirements of an aeronautical engine may be briefly summed up as:

1. Low weight power ratio, which means lightness in proportion to the power delivered at the propeller.
2. Economy of fuel and oil, so as to obtain the maximum radius of action with a given quantity of fuel.
3. Reliability, since no extensive repairs are possible in flight.

In the demand for low weight per horsepower, the requirement of low fuel and oil consumption per horsepower hour is included, since for practical purposes it is necessary to carry enough fuel for a running time of several hours. For long continuous flights, an inherently light engine may easily prove inferior to one of a heavier construction which has a better fuel economy.



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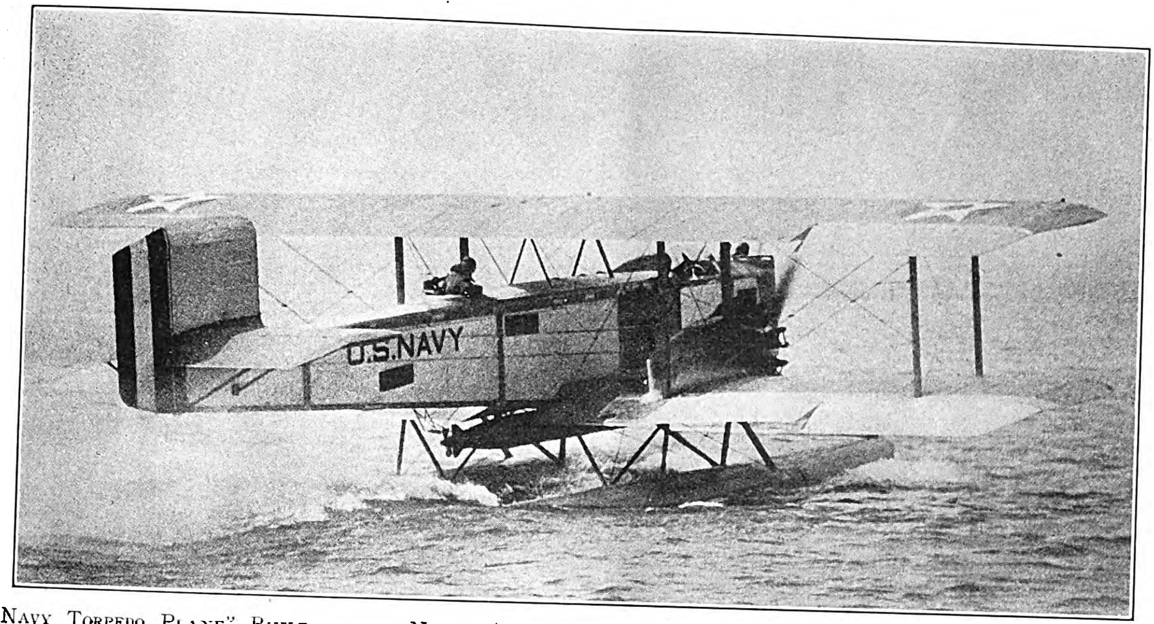
Hand in hand with reliability goes the demand for durability. An aero engine runs almost constantly under full load, and deficient operation, however slight, is a bad feature and one which will kill an engine's chance of survival in service quicker than any other. A decrease in speed of only a few revolutions below normal in a heavily loaded airplane is often quite sufficient to bring about a forced landing.

In considering the fundamentals of design of internal combustion engines for aeronautical use the engine is considered primarily as a heat member, and the problems of carburetion, ignition, lubrication, cooling, etc., are all considered in relation to the adaptability, reliability and weight of the proposed design.

The greater the thermal efficiency of any engine the less the fuel used in pounds per horsepower per hour and consequently the less the overall weight.

There is probably no form of prime mover in existence that is more highly stressed or that has a more strenuous life than the aeronautical engine, and there is undoubtedly no engine that has greater claims on reliability. The demands are for extremely light economical engines, such that probably 90% of the factors which determine the most successful aeroplane are governed directly or indirectly by the weight efficiency and fuel efficiency of the engine. By weight efficiency is meant the pounds of weight per horsepower developed.

Lightness is attained largely by designing for maximum M.E.P. at the maximum feasible speed, and by the intelligent use of materials of selected kinds and cross sections. Alloy steels, properly heat treated, are nearly five times as strong as ordinary cast steel, and are used for crankshafts, connecting rods and other highly stressed parts. Aluminum alloy and sheet metal are used for parts that need not possess much strength, such as water jackets, crankcases, pumps and manifolds. Cylinders are often of cast aluminum alloy, but need to be lined with an iron or steel shell to give the necessary strength and wearing qualities. There are possibilities in the use of magnesium alloy for cylinder liners. Pistons for airplane engines are almost invariably made of aluminum composition, known variously as Magnalite, Lynite, etc. Copper, forming about 8 per cent, is usually the alloying material, although zinc is used to a slight extent and in some cases nickel is a constituent. Aluminum is advantageous mainly because of its lightness and superior heat conductivity, although the fact that it will not rust is important, and it makes a satisfactory bearing for piston pins without being bushed. The main difficulty that has limited its usefulness is in properly providing for differences of expansion, since the coefficient of expansion is so high. It expands twice as much as iron or steel for a given temperature change, which practically precludes its use for large block castings. Fortunately, in using steel liners with cast aluminum outer walls, the latter are in contact with the cooling water while the steel sleeve is in direct contact with the hot gases, which practically equalizes the expansion. When aluminum is used for cylinder heads, it becomes necessary to provide iron or bronze valve seats, because aluminum is too soft and malleable to stand up under the constant hammering of a valve. There are three ways of providing iron or bronze seats, namely: (1) casting an iron ring integral with the aluminum cylinder

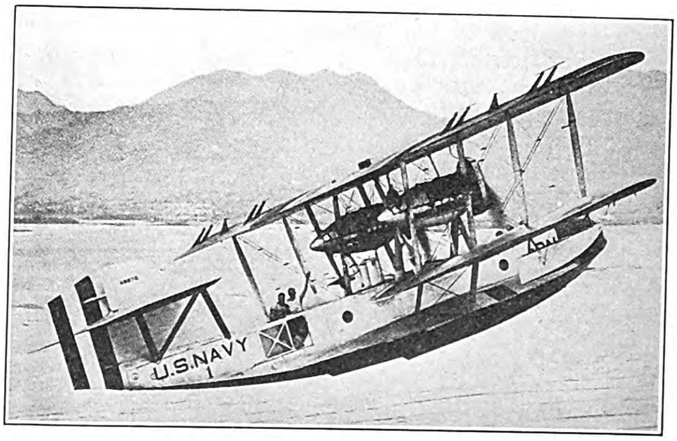


TN-1 "NAVY TORPEDO PLANE" BUILT AT THE NAVAL AIRCRAFT FACTORY. TOTAL WEIGHT 10,500 LBS., CRUISING RADIUS 1000 MILES, CREW THREE MEN. THIS PLANE IS AT PRESENT UNDERGOING ITS SERVICE TRIALS. POWERED WITH TWO AIR-COOLED WRIGHT P-2 ENGINES.

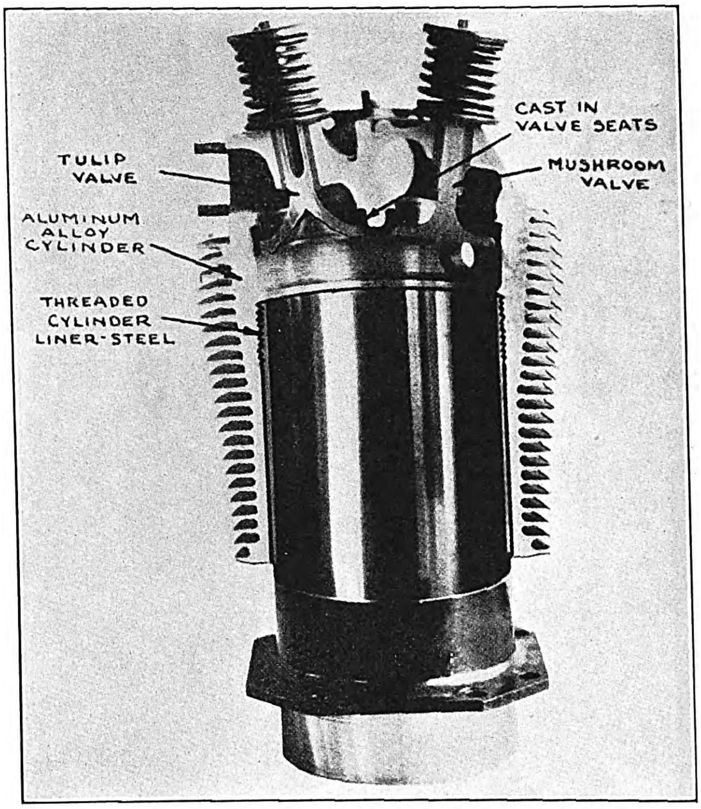
head; (2) threading the ring and screwing it into place; or (3) using a separate valve cage, which has the valve seat and the stem guide integral. Passages for oil through alumnium castings need to be lined with steel tubes, to prevent high pressure oil from breaking through porous places. Threads in alumninum are apt to cut out or shear unless a permanent steel insert is provided.

Next in importance to the kind of material is the form or shape of the section. Connecting rods are usually of I or H section, and sometimes tubular. Crankshafts, camshafts, wristpins and other round pieces are made hollow. Such shapes get the most strength out of a given weight of metal by distributing the metal where it can do the most good, away from the center of gravity. Pistons and crankcases are webbed for stiffness and strength instead of using thick, heavy walls. In the case of V-type engines, forked connecting rods are sometimes used to minimize the length and weight of the engine, although they are more costly and difficult to manufacture. Bearing caps are now tied directly to the cylinders by through bolts, thus making the stress direct and eliminating most of the strain from the walls of the crankcase.

Progress in aircraft engine development is reflected in the fact that we now have proved engines in horsepowers ranging from 60 to 800. In the 60 H.P. class there is the Lawrance 3 cylinder radial type. In the 200 H.P. class there is the Wright "J" aircooled and the Wright "E" watercooled types. In the 300-400 H.P. class the Curtiss D-12, a 12 cylinder water cooled is giving excellent service, especially for use in fast pursuit planes. In the 400-500 H.P. class we have the old tried and true though somewhat heavy Liberty, the Packard 3A-1500 and Curtis V-1400 engines; these are all 12 cylinder water cooled engines. In the 450-500 H.P. class we have the Wright "P-2" and the Pratt and Whitney "Wasp." These are 9 cylinder radial air cooled engines and have been developed to such an extent that they are now comparable in reliability and durability to the best of the water cooled engines and are far lighter in weight, as well as not requiring the added weight of cooling water and radiators, and in addition the air cooled engine does not have the added complication inherent in the "plumbing" necessary with a water cooled engine. In the 500-600 H.P. class the Wright T-3 water



PN-9 "NAVAL PATROL PLANE" BUILT AT THE NAVAL AIRCRAFT FACTORY. TOTAL WEIGHT 19,600 LBS., CRUISING RADIUS 2050 MILES, CREW FIVE MEN. THIS PLANE HOLDS THE WORLD'S ENDURANCE RECORD FOR SEAPLANES HAVING MADE 28 HOURS, 35 MINUTES, 27 SECONDS AND ALSO HOLDS THE WORLD'S RECORD FOR THE LONGEST DISTANCE OVER WATER FOR A SEAPLANE MADE DURING ITS FLIGHT TO HAWAII. POWERED WITH TWO WATER-COOLED PACKARD ENGINES.



SECTION VIEW OF A "WRIGHT WHIRLWIND" CYLINDER SHOWING HOW THE STEEL CYLINDER LINER IS SCREWED INTO THE ALUMINUM ALLOY MUFF, WHICH HAS CAST-ON COOLING FINS. A TULIP TYPE SILCHROME STEEL VALVE IS USED ON THE EXHAUST, SEATING ON THE HARDENED BRONZE SHRUNK AND EXPANDED VALVE SEATS.

cooled engine is meeting the present requirements very satisfactorily. In the 600-800 H.P. class the Packard 3A-2500 water cooled engine is being used. In the past few years great strides have been made in the matter of reliability and increased service between overhauls. In service we are getting a life between overhauls of from two to four times as great as from previous engines. It is not an unusual event now to have reports of engines going 400 to 450 hours between overhauls, and assuming the lower speed of 90 miles per hour for an airplane this would mean a mileage of from 36,000 to 40,000, and admittedly this is a much better showing than the best automobile engine can make.

The only apparent limitation to the air-cooled development is the fact that air cooling, at its best, is far less efficient than water cooling, because of the comparatively low specific heat and the low specific weight of air. With inefficient cooling, cylinders must be smaller in order to prevent overheating and great attention must be given to the engine cowling to insure that the proper air blast is guided evenly around the cylinders. Furthermore, compression must be lower in air cooled engines to avoid preignition. These factors limit the horsepower developable per cylinder, and from the present indications horse powers of 60-70 per cylinder may be efficiently obtained from air cooled engines, and for powers up to 100 horse power per cylinder we must rely on the more efficient water cooling.

Tests of the Fatigue Strength of Cast Iron

Very few test data are available on the capacity of gray cast iron to resist repeated stress. In general, gray cast iron is not widely used for machine and structural parts subjected to repeated stress, but cylinders of steam engines, internal combustion engines, and pumps, pistons, valves, cast-iron water and gas pipes, parts of machine tools, machine frames, and levers in the weighing mechanism of scales and testing machines are common examples of cast-iron parts subjected to repeated stress, although fatigue strength is not usually the major factor.

The Allis-Chalmers Manufacturing Company of Milwaukee, Wisconsin, recently made arrangements for a series of fatigue tests of gray cast iron to be made in the laboratories of the Investigation of the Fatigue of Metals at the University of Illinois. The information secured in the carrying out of these tests by no means covers the entire subject of fatigue strength of cast iron, but it is believed that the publication of these test results is justified in view of the meager amount of data available.

Bulletin No. 164. Price, 30c. Engineering Experiment Station, Urbana, Ill.

A Study of Fatigue Cracks in Car Axles

The occasional failure of car axles and locomotive axles under repeated service stresses led to the classical series of repeated-stress tests carried out by Wohler between the years 1859 and 1870. Failures of car axles in service have been rare, but when one does occur it is likely to lead to a serious disaster; and railroad engineers have always been interested in methods of inspection designed to prevent such failures by detecting the minute cracks, which mark the beginning of failure under repeated stress, before they spread to fracture of the axle.

In 1924 a group of the Public Utilities Companies of Northern Illinois entered into co-operative relation with the University of Illinois for the study of several research problems. Among these problems was a study of failure of car axles under repeated stress (fatigue failures, as it is called) with special attention to the effectiveness of shop methods for detecting fatigue cracks before they had spread to complete failure. This bulletin is a report of the study of this problem.

Bulletin No. 165. Price, 15c. Engineering Experiment Station, Urbana, Ill.

Recent European Motive Power Developments

Digest of a Paper presented by Charles B. Page, Chicago, before the Western Society of Engineers, March 21, 1927. The information presented was obtained by the author during two trips abroad, the first of which was in the company of the late Mr. W. H. Finley, a former President of the Chicago & North Western Railway Company.

DURING 1926, main line electrification made considerable progress, particularly in Switzerland. It is planned ultimately to completely electrify the Swiss State Railways, which comprise 1,475 route miles. In 1926, 120 miles were electrified, and it is proposed to add 200 miles more during 1927. Switzerland produces no coal; water power is cheap and everywhere available with short transmission lines, tunnels are numerous and frequently long, and grades are heavy. Conditions are thus ideal for general electrification.

A number of builders throughout Europe are producing electric locomotives. In a recent design of Brown Boveri, of Baden, side rods are eliminated, the motors driving a large bull gear through a pinion. The large gear is located outside the driver and is normally concentric with the axle. A peculiar linkage permits a relative vertical motion of the driving wheel without disturbing the gears.

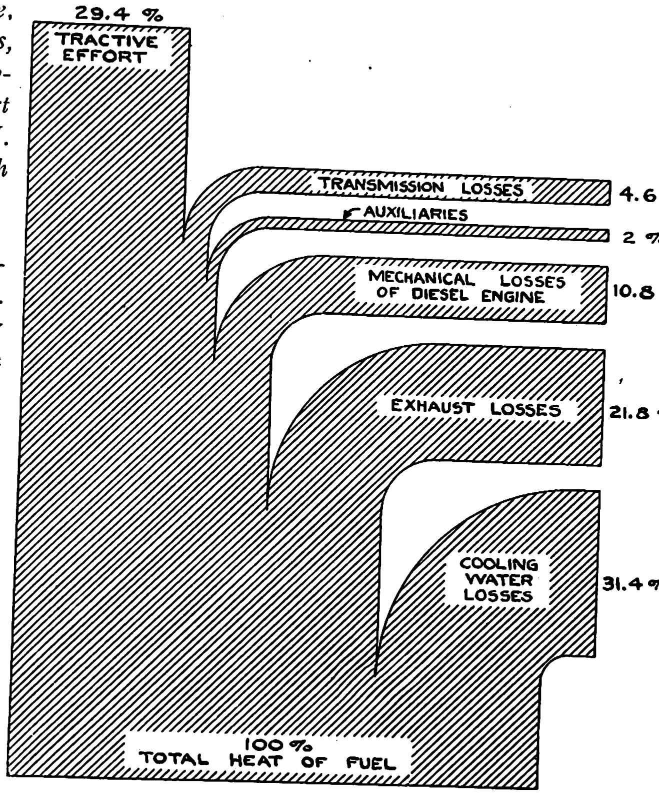
Deisel Locomotive Developments.

The outstanding Diesel locomotive built in Europe in 1926 was the so-called second Russian locomotive designed by Professor Lomonossoff, of the Russian State Railways, and the Hohenzollern Locomotive Works, Dusseldorf, and built jointly by Hohenzollern, M. A. N. (Machine Works, Augsburg-Nuernberg) Magnet Werke and Krupp.

The engine of this locomotive is a six cylinder, air-injection type, developing 1,200 horse-power at 450 r.p.m. The transmission has three speeds, the maximum being 34 miles per hour, and is arranged with constant mesh gearing and magnetic clutches. Backward motion is effected by reversing the engine.

The thermal efficiency of the engine is 34%, and of the entire locomotive 29.4%. The latter figure compares with the 25% efficiency of Professor Lomonossoff's first Diesel locomotive, which had an electric drive.

The new locomotive has been tested in both Russia and Germany, and while some weak points developed, the results have encouraged the German builders to project a 1600 horse-power locomotive with gear drive of six speeds forward and reverse, and air clutches.



Diesel locomotives have also been built, or are under construction, by the Esslinger Machine Works near Stuttgart, Linke-Hoffman of Breslau, and the Berliner Machine Works, Berlin. The last two builders used hydraulic transmission. In Sweden, a switching unit to be equipped with Rosen hydraulic gear, is being developed.

While in the United States, electric transmission is favored for Diesel locomotives, the present trend in Europe is towards a mechanical transmission; and for road locomotives, the constant mesh gear drive with magnetic or pneumatic clutches is regarded with the most favor. Interest is also expressed in a compressed air drive. Attention is being given chiefly to road locomotives of 1000 horse-power and up, the construction of small switching locomotives having practically ceased.

Rail Cars for Light Service

Automobile and bus competition is forcing European railways into motorized equipment, and during 1925 the Continental countries ordered 182 rail cars. Approximately 50 of these were ordered by the various State Railways, and the balance by municipalities and privately owned branch and industrial lines.

In 1926, the German Railways authorized the construction of 40 cars, benzol and Diesel powered, each of 150 horse-power and with mechanical drive. The engine with transmission is mounted on a sub-frame independent of the body, which frame can be detached and lowered into a pit, and replaced by a spare unit, in a period of two hours. The cars have a length of 60 feet and a seating capacity of 81.

The German railways propose considering rail cars up to 300 horse-power only. Above this power, steam is preferred, and for this service a 300 horse-power tank locomotive, with a mechanical stoker and designed for one-man operation, is now being developed.

In England, instead of using rail cars, the tendency is to adopt a four-wheeled steam driven unit, to which is articulated a light weight combination baggage and passenger coach. The maximum horse-power per unit is about 125, with a speed limit of 40 miles per hour.

Higher Steam Pressures

Practically all European locomotive builders are studying the question of greatly increased steam pressure—850 pounds per square inch and up. The locomotive built by Henschel & Sohn, Cassel, Germany, under the patents and to the designs and specifications of the Schmid-Heissdampf Gesellshaft, which carries a working pressure of 850 pounds, has been exhaustively tested, and is stated to show a gain in eocnomy of at least 25% as compared with superheater locomotives carrying ordinary pressures.

In the Henschel locomotive, steam is primarily generated at a pressure of 1,000 to 1,200 pounds per square inch, in water tubes which surround the firebox. The heat in this steam is utilized in generating steam at a pressure of 850 pounds, in a drum located over the combustion chamber. This steam is superheated and expanded in a high pressure cylinder located between the frames. The exhaust from the high pressure cylinder passes to two outside low pressure cylinders which receive an additional supply of highly superheated steam, generated at a pressure of 200 pounds in a tubular boiler. This locomotive is of 2,500 indicated horse-power capacity, and has a maximum speed of 75 miles per hour.

High-pressure locomotives are also being developed by the Berliner Machine Works, the Swiss Locomotive & Machine Works (Winterthur), and the Krupp Works.

Turbine Drive Condensing Locomotives

Considerable interest is being shown in turbine driven locomotives, particularly two types — the Ljungstrom and Zoelly. The first Ljungstrom locomotive was completed in 1922, and was extensively tested in the laboratory and on the Swedish State Railways. At about the same time Escher-Wyss & Co., of Zurich, using a converted 1,000 horse-power Swiss Railway locomotive as a basis, developed the Zoelly system.

These two locomotives made such a favorable impression that several prominent builders undertook the development of turbine locomotives. The result may be briefly outlined as follows:

The Krupp Works have developed a 2,000 horse-power locomotive of the Zoelly type, which subsequent to its initial trials, was considerably modified in construction. A feature of this design is an auxiliary overload valve, by which the horse-power of the main turbine can be increased from a normal of 2,000 to a maximum of 2,800.

Henschel & Son have applied a turbine-driven tender to a 1,000 horse-power locomotive of the German Railways, the turbine using the exhaust steam from the cylinders of the locomotive.

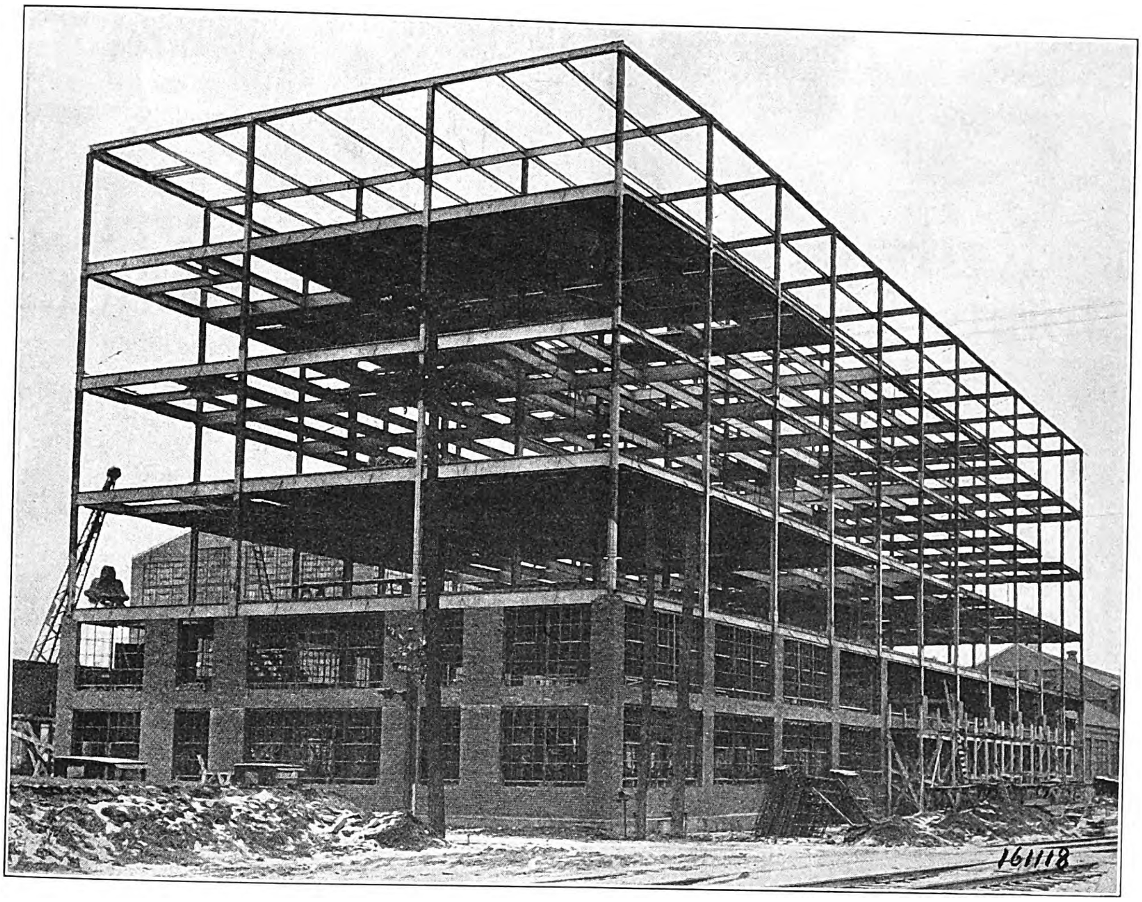
In the fall of 1926, J. A. Maffei, of Munich, completed for the German Railways, a 2,500 horse-power locomotive, which is somewhat similar to the Zoelly system. This locomotive was given extensive builders' trials, and was then placed in express train service between Munich and Augsburg, a distance of 70 miles.

Early in 1926, Nydquist & Holm, of Trollhattan, Sweden, built a Ljungstrom type locomotive of 1,750 horse-power, for the Argentine State Railways. This locomotive is reported to be highly successful, showing important economies in fuel and water consumption, with reduced maintenance expense.

The same company has recently built a 2,000 horse-power locomotive for the Swedish State Railways, which is successfully making a run of 392 miles per day.

Beyer, Peacock & Co., Ltd., of Manchester, England, have built a 2,000 horse-power locomotive of the Ljungstrom type, which is giving good results in heavy express passenger service on the London, Midland & Scottish Railway.

Various builders are now working out designs for large turbine locomotives carrying high steam pressures, and the outlook for this type of power seems to be most promising. All this work is in line with the present tendency, in stationary and marine practice, to develop large turbines using high steam pressures. The Diesel locomotive will be built to some extent in the future, but main dependence will be placed on steam power. The possibilities of the turbo-condensing type are illustrated by a locomotive now being designed by German engineers, which is expected to develop a thermal efficiency of 17 to 19 per cent as against 7 to 8 per cent for the modern superheater locomotive. It can now be predicted that within the next few years, steam locomotives of 4,000 to 5,000 horse-power will be built, that will be essentially smokeless and noiseless, of weights and dimensions within necessary limitation, largely independent of roundhouse service, and produced at a reasonable cost.



Welded Structure at Sharon, Pa.

Welding and Riveting as Applied to Structural Steel Members*

Introductory Remarks

By F. MALCOLM FARMER

President American Welding Society

YOU have an interesting subject tonight, one which is going to be very actively discussed for some time not only in the welding field, but in other fields. Unfortunately, I know very little about welding and less yet about riveting. It is true that I have, in my contact with the Welding Society, absorbed a little information about welding and also I am afraid considerable misinformation. While, therefore, I can't talk to you about the technical matters pertaining to welding, I can make a comment upon the general subject of the evening, namely, welding versus riveting.

At the meeting of our Society in Buffalo last fall, I made an unfortunate choice of words in discussing this same subject. I made some reference to the time when "welding would replace riveting." I was very promptly and very effectively, but very courteously called to order. My attention was called to the fact that we should not talk about welding **replacing** riveting, but rather about welding **supplementing** riveting. And so I wish to emphasize that idea. I want to make a plea for moderation in our discussion of this subject. Our friends who are interested in the riveting method of securing structural members are not going out of business tomorrow. They are going to remain in the picture, and our cue is to work with them and not against them. I would ask that we co-operate with them on the proposition that as engineers we are committed to the forwarding of that process which is the best for the general good of all, which is the best for industry as a whole. We as engineers should confine our discussions to facts, deal only with facts, and then let the facts speak for themselves. After all the law of the survival of the fittest is inflexible in the industrial world. That process is going to be used, whether it is riveting, welding or anything else, which is the best when all things such as safety, economy, etc., are considered. Individual opinions, acrimonious discussion and biased statements will have no weight whatever. That process which is the best in the end is going to be used no matter what any of us think about it, or what we say about it. So I say our cue is to cooperate with the other interests in the structural field for the common good of the entire industry.

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*General subject at meeting held February 21, 1927, under auspices of The Engineers' Club with the co-operation of the American Welding Society (Philadelphia Section).

The Rational Design of Structural Steel Joints for Arc-Welded Connections

By A. M. CANDY,
East Pittsburgh, Pa.

THE designs of joints which we call our rational design, are not necessarily the last word by any means. They are simply suggested joints, and are departures in most cases from what we ordinarily find in riveting construction. Our idea back of the whole thing is to try to get industry to think of joints in terms of welding rather than in terms of riveting. A number of specimens were made at East Pittsburgh about a year ago, and tested at the Carnegie Institute of Technology last summer. I am not going into the history of just why that work was undertaken, but I will say this, that those of us who have been connected with the arc-welding industry for over a decade have been dreaming about erecting buildings using the arc-welding process, and we have talked a lot about it; we have written about it. Finally we decided that talk and writing would not get us anywhere, and that we would like to see something done on a reasonable scale. With that in view, specimens were designed and tested.

By these tests we believe that we have demonstrated a number of facts. In the first place, absolute fixation can be obtained between beams and girders, or beams and columns. Lines of beams, or lines of girders, can be made continuous throughout their supports. Whether or not it is going to work out in practice that it is economical to take full advantage of these features remains to be seen. The degree of fixation which we get gives us a rigidity of the structure which in many cases should help, we believe, to reduce the amount of wind bracing required in the structure. Furthermore, by designs which we have in mind, and undoubtedly improvement in these designs in the future, the increase in the saving of steel for buildings may be even greater than any savings we have been able to make so far, which have been on the order of 10%. In addition to possible savings in material and labor, there are some slight advantages to the welding process. In the first place welding to a certain extent will help to minimize the problem of corrosion. I don't mean that simply because a structure is welded it is not going to rust. A welded structure will be easier to paint, because the bare corners which we ordinarily have in riveted work (right angle corners in many cases) will be filled in with weld fillets; in many cases, the members will not overlap at all. The surfaces of the welded joints are much smoother than where we have rivet heads which must be painted around with either a paint brush or a spray gun. Furthermore, where we do have overlapping members, if they are to be exposed to elements any length of time it is entirely possible to seal around the overlapping members and in that way prevent water from working back into the structure.

Probably one of the biggest advantages of welding will be where changes are required in existing structures, regardless of whether those structures have been erected by the riveting process, or by the welding process. It is very easy to see that if a change is required in a building, or room, for example, it is only necessary to make bare one face of the column, set the essential members in place and weld around the ends, whereas in riveting it is necessary to get back of the column in order to back up the rivets in driving them.

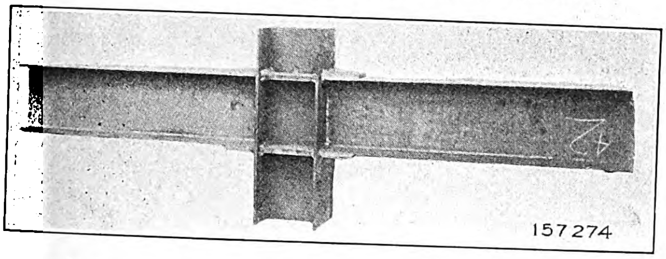
There were 42 specimens made up for testing. In making these specimens, all of the work which was considered shop fabrication work was done with the specimen in the position in which it was easiest to make the weld. In other words, the welders were allowed to turn them on a table. For instance, the continuity plates and seat angles were welded on the columns with the column in the best position. In every case where a connection was made that would represent a field connection, the specimen was turned until it was in the position which would represent field conditions, so that the work was carried out exactly as it would be on a structure. Furthermore, these specimens were made in duplicate. One set was painted with a wash of cement in order to bring out the stress lines more clearly in photography.

The 42 test specimens required approximately 14 tons of structural shapes and plates. After a study of the results of these tests a building 70x220 feet by 80 feet high and requiring 790 tons of steel was erected at the Sharon, Pa., works of the Westinghouse Electric and Mnaufacturing Co. of East Pittsburgh, Pa.

Space limitations will not permit an exhaustive account of the study of all the specimens and, therefore, only the most interesting and valuable ones will be considered. In addition, however, some interesting shock test specimens will also be introduced.

The design of column connections offers a very interesting study in that continuity may be obtained with arc welding at much less expense than where riveted designs are used. Furthermore, the welded connections are stronger than the conventional riveted connections.

To substantiate these ideas a series of three test specimens were built as illustrated by Photo. 157274 and 158774. Each specimen comprises an H column eight inches deep, two feet high, weighing 32 pounds per foot and two cantilever Bethlehem I beams nine inches deep, three feet long, weighing 29.5 pounds per foot. The detail connections for the specimen are as follows: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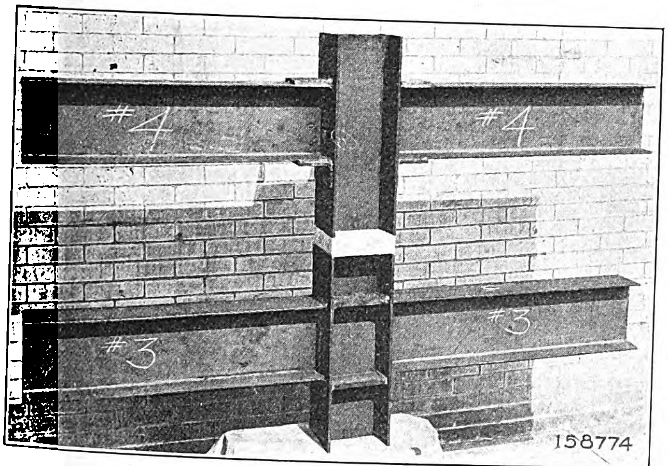
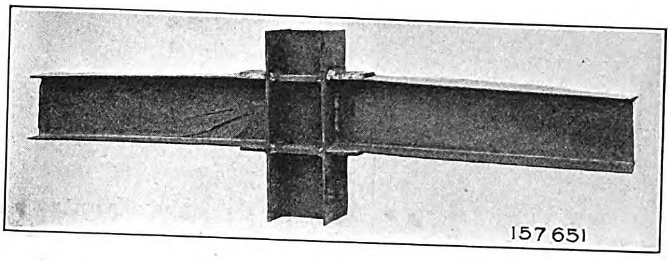

158774

Specimen No. 2 was constructed by welding two seat angles 4"x3"x3/8"x6½" long, across the faces of the column with the 4" legs outstanding. Only the ends of the 3" legs were welded to the column with a 5/16" bead. This welding was done in a downward direction by turning the column to typify shop fabrication. Four continuity plates each 3"x5/8"x6⅝" long were then located against the web of the column between flanges so as to be directly in line with the flanges of the cantilever beam. The column was turned to permit all downward welding the same as for the seat angles. These continuity plates were heavily welded with a 3/8" fillet entirely around their ends against the column flanges. The column was then placed on end and the I beams were landed on the seat angles with approximately a 3/16" opening between the beam ends and the column faces. The entire ends of the beams were then welded to the column faces. Also the edges of the beams were welded four inches along the line of the outstanding legs of the seat angles. Two top reenforcing plates each 4"x½"x4½" were then located on top of the beams with the 4" lengths adjacent to the column faces. These ends were welded to the column faces and the 4½" lengths were welded to the top flanges of the beams.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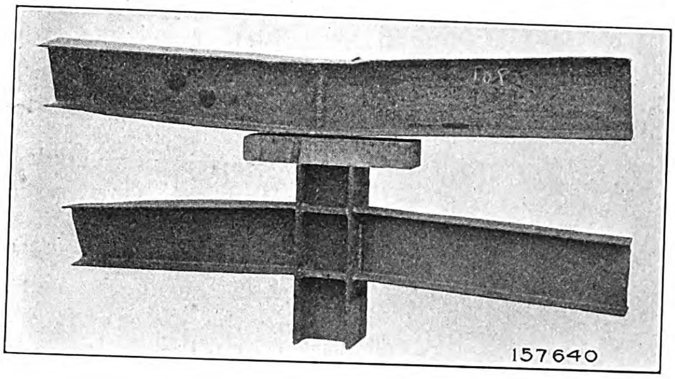
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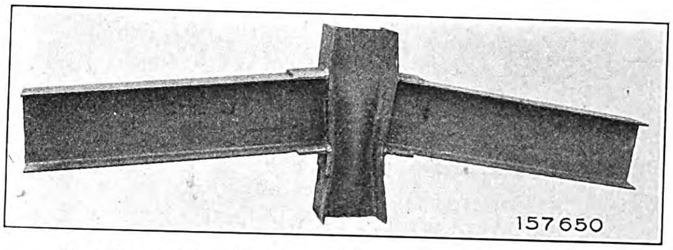
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Specimen No. 3 differed from No. 2 in that no seat angles and no reenforcing plates were used.

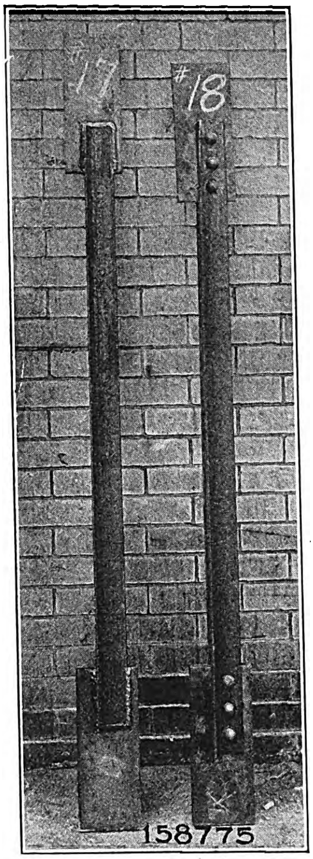
Specimen No. 4 differed from No. 2 in the very vital item of omitting the "continuity" plates from the column flanges.

Each of these specimens was turned upside down and mounted on rocker blocks 5" wide located with their centers 3" from the beam ends, thereby providing a span of approximately 6' 2½", the load being applied on the upstanding end of the column.

The results of the tests are shown by Photo. 157651 for No. 2, 157640 for No. 3 and 157650 for No. 4. The following table gives the pertinent data:

Specimen No.	Pounds Elastic Limit	Pounds Ultimate Load	Bending Moment at Column Face in Inch Pounds	Remarks on Ultimate Load
2	57000	70000	1,165,000	No. 2—31% higher than No. 4
3	50000	68550	1,130,000	No. 3—28% higher than No. 4
4	28000	53400	878,000	No. 2— 2% higher than No. 3

It is interesting to observe that none of the specimens had a single failure in the welds. Specimens No. 2 and No. 3 failed by web crippling of the cantilever beams and No. 4 by web buckling of the column. The fact that No. 2 shows 2% greater ultimate capacity than No. 3 is attributed to the stiffening effect both in the vertical and horizontal planes produced by the top reenforcing plates and the outstanding legs of the seat angles. The very marked difference between No. 2 and No. 4 is, of course, due to the "continuity" plates in the column of No. 2 which produce an effect identical with that of having the



158775

two cantilever beams carried continuously through the column. This construction is carried out completely through the Westinghouse Sharon building.

To show the advantages gained by simply substituting arc welding for riveting in tension members, two specimens were prepared as shown by No. 17 and No. 18 in Photo. 158775. Specimen No. 17 comprises two angles 2½"x2"x$\frac{3}{16}$"x4' long with their 2½" legs located against two shank plates ¾"x5"x1' long with the angles over-lapping the plate ends 4". The heel and toe of each angle was welded along the 4" length and across the ends of each angle to the shank plates. Specimen No. 18 differed slightly in that the angles were 4' 2½" long, over-lapped the shank plates by 6½" and were riveted to the shank plates with six rivets ⅝" diameter, power driven in $\frac{11}{16}$" diameter holes.

The welded specimen (No. 17) failed through the 2½" leg first, followed by tearing through the 2" leg adjacent to the end of the shank plates. The riveted (No. 18) specimen failed through the first rivet hole at the end of the shank plate.

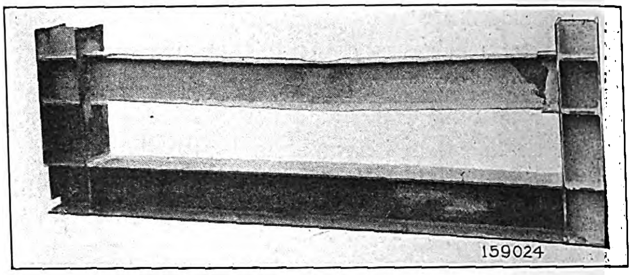
The following table gives the pertinent data:

Specimen No.	Pounds Elastic Limit	Pounds Ultimate Load	Ultimate load in pounds per sq. in. of sectional area of the two angles
17	70000	94000	58000
18	60000	72000	44500

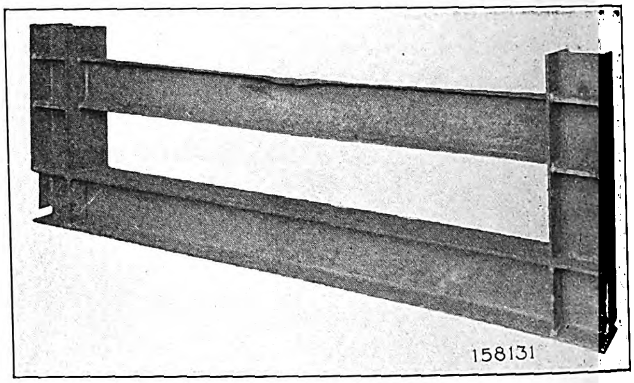
In addition to the fact that the welded specimen was more than 30% stronger than the riveted specimen it is interesting to note in passing that the elongation of the welded specimen was 168% greater than the riveted specimen, the values being 1.12" over a length of 4' 3½" for the riveted specimen and 3" for the welded specimen measured over a length of 40".

I must say right here, in all fairness to riveted construction, that none of our tests resulted in the failure of a single rivet. In fact, it is the hole that causes the trouble. I was just wondering, when looking over the program, if the papers committee didn't really make a mistake, and if they shouldn't have also scheduled a paper on The Hole as well as The Rivet, because it is the hole that needs the defense, and not the rivet.

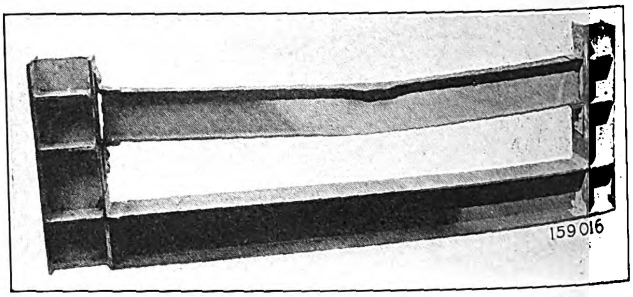
A series of three simple beam specimens were constructed and tested as per photo. 159024-158131-159016. For each of the three specimens identical super-structure to support the beams were constructed by arc welding using 10" H sections weighing 49.5 pounds per foot, the base section being 9' 7¾" long and the column sections being 2' 3" high. The "continuity" plates were ⅝"x4"x8¼" long. The back stress plates tying the column faces to the base web were ½"x6"x1' 4" long. The beam member of each specimen was a 9" I weighing 21.8 pounds per foot, 7' 11⅜" long.



159024



158131



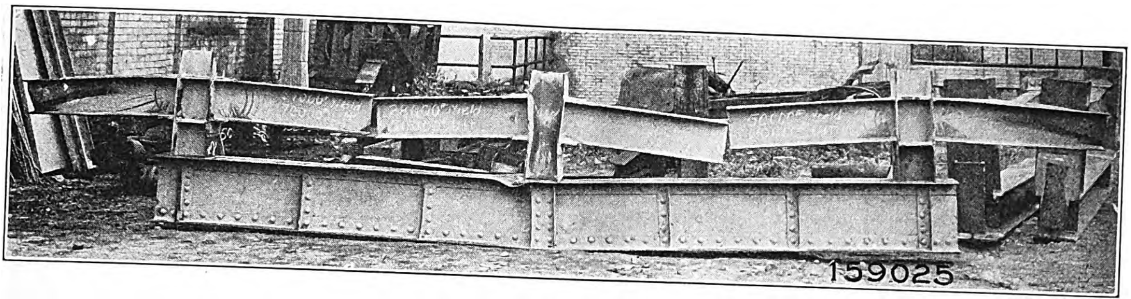
159016

In the case of specimen No. 7, Photo 159024, two seat angles 3"x4"x⅜"x5" long, were welded along the ends of the 3" leg to the columns. The structure was then turned in the upright position and the beam was landed in position on these seat angles. The beam ends were then welded to the column faces and landing angle; also reenforcing top plates 4"x$\frac{7}{16}$"x5" long, were added and welded exactly as described for specimen No. 2.

Specimen No. 8, Photo. 158131, differs only from No. 7 by the omission of seat angles and top reenforcing plates for the beam to column connection.

Specimen No. 9, Photo. 159016, is materially different in that the beam to column connections follow standard riveted practice. Two top and bottom angles ½" thick and a total of twenty rivets ¾" in diameter, power driven in $\frac{13}{16}$" diameter holes were used.

Each of the specimens was centrally loaded on a block 1½"x5"x8" long placed with the 8" dimension across the top flange of the beam. In each of the three specimens failure took place by web crippling and flange



159025

buckling, at the center of the beam as per Photos. 159024, 158131 and 159016. It is interesting to note, however, that in the case of the riveted specimen No. 9, although the major failure was web crippling at the center of the beam, a preliminary failure by bending of the top angles produced a V-shaped opening between the beam end and column faces as illustrated at left end of beam in Photo. 159016. This preliminary failure of the top angles was responsible for the early ultimate failure of the specimen

Specimen No.	Pounds Elastic Limit	Pounds Ultimate Load	Remarks on Ultimate Load
7	50000	73500	No. 7—25% higher than No. 9
8	50000	67200	No. 8—14% higher than No. 9
9	42000	58700	No. 7— 9% higher than No. 8

As in the case of specimens No. 2 and No. 3, we attribute the superiority of No. 7 over No. 8 to the stiffening effect, in both vertical and horizontal planes, produced by the top reenforcing plates and the outstanding legs of the seat angles.

It is interesting to observe that in the case of specimen No. 7 the weight of the seat angles, top reenforcing plates and weld metal to attach the beam to the columns was 11 lbs. whereas for specimen No. 8 only 2 lbs. of weld metal was required for the same connection. But in the case of the riveted specimen No. 9 the top and bottom angles and rivets weighed 22 lbs. The comparison on this basis is set forth in the following table:

Specimen No.	Pounds of Connection Material	Remarks on Relative Weights
7	11	No. 7 is 50% of No. 9
8	2	No. 8 is 9% of No. 9
9	22	No. 8 is 18% of No. 7

It is interesting to observe that whereas No. 7 is 25% stronger than No. 9 only 50% of the connecting material is required. Likewise, No. 8 is 14% stronger than No. 9 with only 9% of the connecting material required. It is believed, however, that No. 7 is the preferred form of construction especially where heavy sections are involved and also because the use of the top reenforcing plate makes overhead welding unnecessary on the under sides of the top flange.

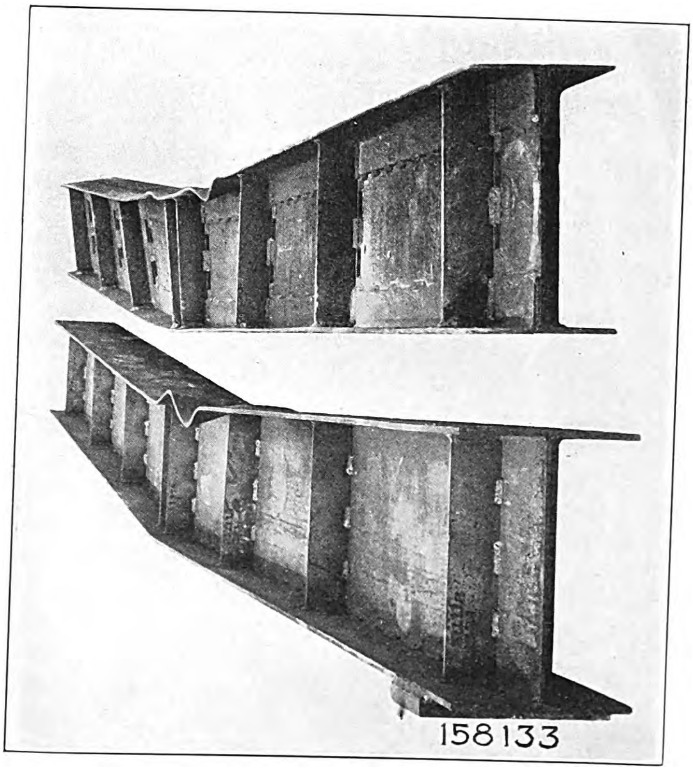
In the case of specimen No. 7 the sum of the positive and negative bending moments was 1,760,000 inch pounds. As the welds showed no distress and as the columns did not perceptibly deflect, the negative moment at either end must have been nearly as great as the positive moment at mid-span. For purposes of comparison with tests 8 and 9; assume this test a case of perfect fixed ends, positive and negative moments being each 880,000 inch pounds. This corresponds to maximum fibre stress* of 46,500 lbs. per sq. inch.

For specimen No. 8 the sum of the positive and negative bending moments was 1,618,000 inch lbs. Assuming same ultimate positive bending moment as in test No. 7, the negative moment at column face would be 738,000 inch lbs., indicating 84% fixation.

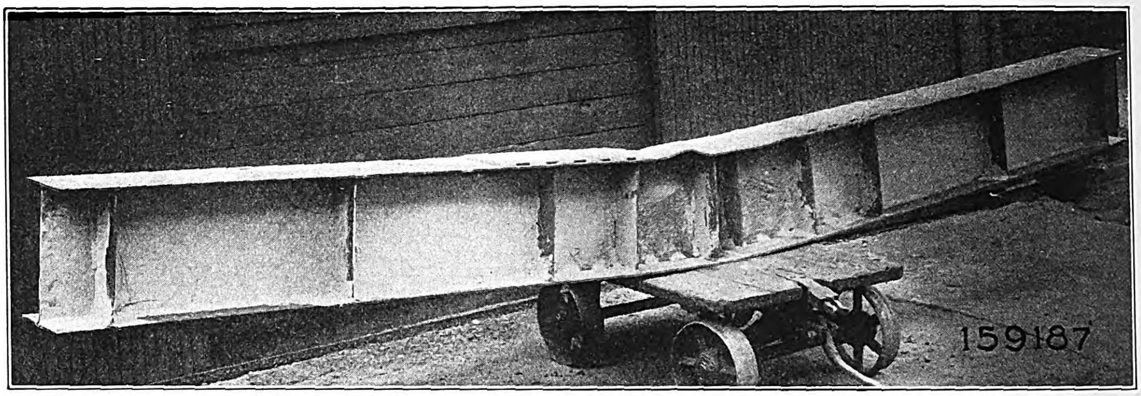
For specimen No. 9 the sum of positive and negative bending moments was 1,410,000 inch lbs. Assuming same ultimate positive bending moment as in test No. 7, negative moment would be 530,000 inch pounds, indicating 60% fixation. Such a degree of fixation could not have been obtained with an ordinary type angle $\frac{5}{16}$" or ⅜" thick.

There is probably no more fertile field for the use of arc welding than that afforded by built-up members, such as girders, columns, etc., which exceed the sizes of existing rolled shapes. For this reason it was decided to build up a series of four specimen girders as illustrated by Photos. 159025, 158133 and 159187.

The riveted specimen No. 20 comprises a web plate $\frac{5}{16}$"x14"x15′ 0"; four flange angles 3"x4"x$\frac{5}{16}$"; sixteen web stiffener angles 2½"x3"x¼" and filler plates. A

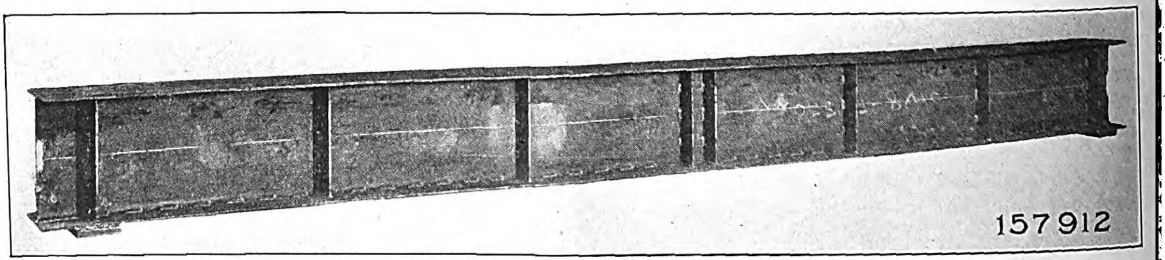


158133



total of 116 rivets ¾″ diameter power driven in $\frac{13}{16}$″ diameter holes were used to fabricate the girder.

Specimen No. 19, Photo. 158133, was constructed of the same parts but assembled by arc welding. The top flange angles were welded to the web plate by intermittent welds 1 in. long on 3 in. centers along the toe of both the top angles. *The backs of the angles were welded together and to the end of the flange plate intermittently using 2 inch long welds on 3 in. centers.* At each end the angles were welded solid to the web plate at both the heel and toe for a distance of 3 in. The bottom flange angles were welded to the web plate solid for a distance of 6″ at each end of the toe, the remainder of the weld along the toe of the angle being 2 in. on 5 in. centers. *The heels of these angles were welded solid and also to the edge of the web plates for a distance of 6 in. The remaining portion of this same joint was intermittently welded 2 in. on 5 in. centers.* The filler plates were welded to the web plate by means of 2 in. long welds at the neutral axis and ½ in. welds at the ends of the filler plates along the web plate. The stiffening angles were completely welded around the entire periphery, making contact with the flange angles and also 2 in. welds at the heel and toe of these angles exactly in line with the 2 in. welds made at the edge of the filler plates to the web plate. The completed specimen weighed 785 pounds. The amount of welding wire required to complete the specimen was 27 pounds 8 ounces. The total time to complete the specimen was 14 hrs. and 10 min.



Specimen No. 21, Photo. 157912, was suggested by the author and was designed strictly to take all advantage of the possibilities of joining structural steel members by the use of arc welding to produce a girder of equal strength using less weight of steel. In this respect it is entirely different from No. 19, which is simply a riveted design welded.

The specimen comprises a web plate 14″x$\frac{5}{16}$″x15′ long; two flange plate, 10″x⅜″x15′ long; and 16 web stiffener plates 3″x¼″x1′ 1¾″ long. The top flange was welded to the web plate continuously along each side of the web plate. The bottom flange was welded to the web plate solid for a distance of 6 in. from each end and then intermittent welds 2 in. long on 4 in. centers the rest of the distance on each side of the web plate. The web stiffeners were welded solid to the flanges around the entire periphery at each end of each web stiffener. Each web stiffener was also welded 2 in. on each side at the neutral axis and at intermediate points 1 in. long at each side of each stiffener half way between the neutral axis and the flanges of the girder. This specimen had a total finished weight of 656 lbs. which is 18% less than that of the riveted girder No. 20, which weighed 798 lbs. and 16% less than (the riveted design welded) specimen No. 19, which weighed 785 lbs.

Specimen No. 21-A, Photo. 159187, was also designed to take all possible advantage of arc welding and to use an amount of steel having about the same weight as the riveted girder No. 20. Its reinforcing plate 9″x$\frac{5}{16}$″x6′ long was welded to the top flange. This plate was welded solid across each end and solid along each edge from the center of the girder to a point 1 ft. 2 in. from the center of the girder. The remaining length of the edge of the plate was welded intermittently 2 in. welds on 4 in. centers. This girder had a completed weight of 795 lbs., and required 30 lbs. 12 ounces of welding wire to complete the welding work. The total welding time was 16 hours and 50 minutes.

All of these girders failed in a very similar manner, namely, principally by buckling of the top flange as per Photo. 158133 for No. 21 and No. 19; Photo. 159023 for No. 20, and Photo. 159187 for No. 21-A.

In the following table the pertinent data is given in which the data given for the specimen No. 20-B is the average of the data for the two specimens No. 20 and 20-A.

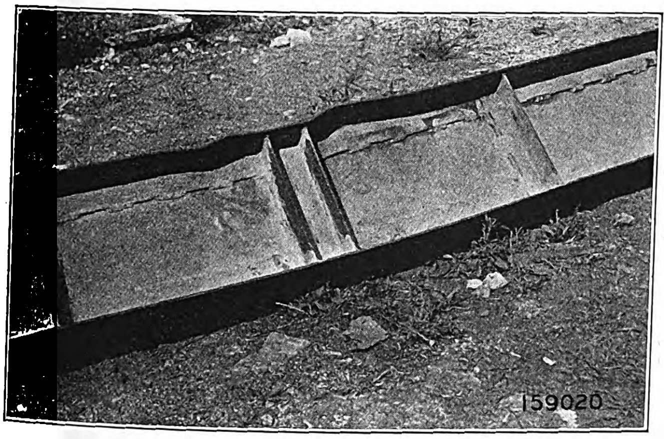
Specimen No.	Pounds Weight	Pounds Elastic Limit	Ultimate Load	Maximum Bending Moment, Ft. Lbs.	Maximum Fibre Stress Lbs. per Sq. In.
19	785	65000	77200	270000	53800
20-B	798	57500	71450	250000	49200
21	656	65000	78000	273000	52700
21-A	795	60000	110350	386000	

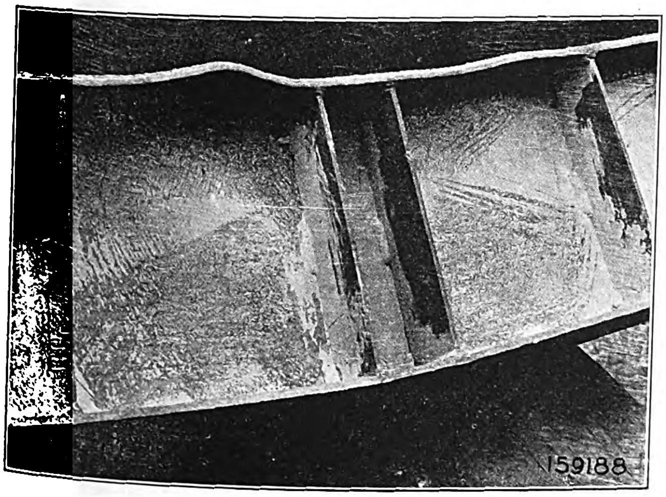
Comparative Data

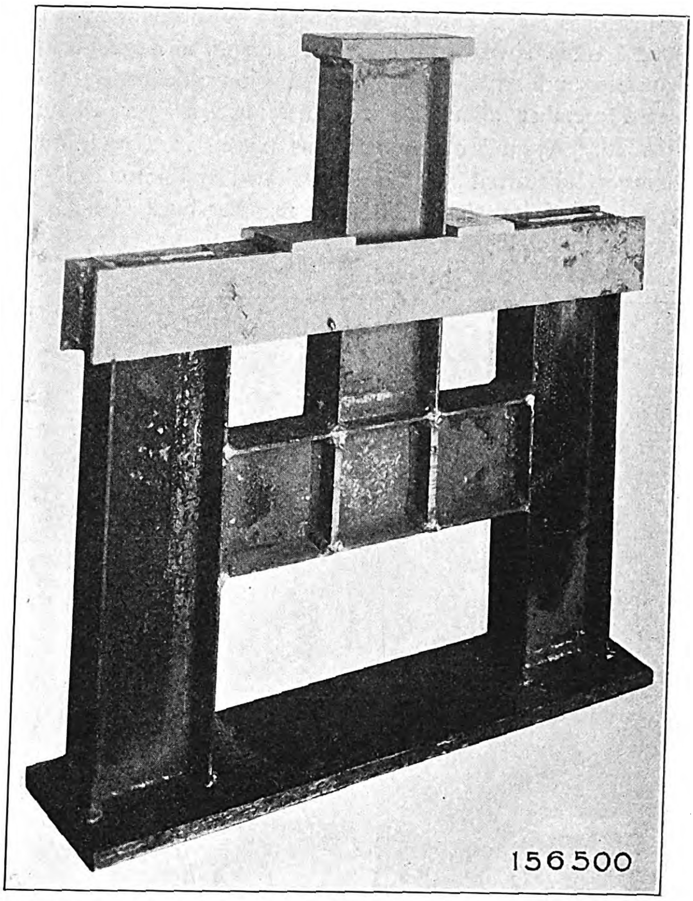
Weight	Ultimate Load
No. 21-A ½% below No. 20-B	No. 21-A is 59% above No. 20-B
No. 21 is 18% below No. 20-B	No. 21 is 9% above No. 20-B
No. 19 is 1½% below No. 20 B	No. 19 is 8% above No. 20-B
No. 21 is 16½% below No. 19	No. 21 is 1% above No. 19

A few deductions of interest may be drawn from these girders, for example, since No. 19 and No. 20 are made up from duplicate parts one should be as strong as the other. We find, however, that although No. 19 is slightly lighter it developed 8% greater strength. This is attributed to the fact that welded connections are much more rigid than riveted connections, but the feature of even greater importance is the fact that the heels of the flange angles were welded together and to the edges of the web plate, which makes the two sets of flange angles practically the equivalent of a solid plate, therefore, materially stiffening these members as compared with the riveted construction.

During the tests of these girders none of the welds showed any signs of distress even at the points of maximum stress. Similarly Photo. 159020 shows specimen No. 19 and Photo. 159188 shows specimen 21-A.

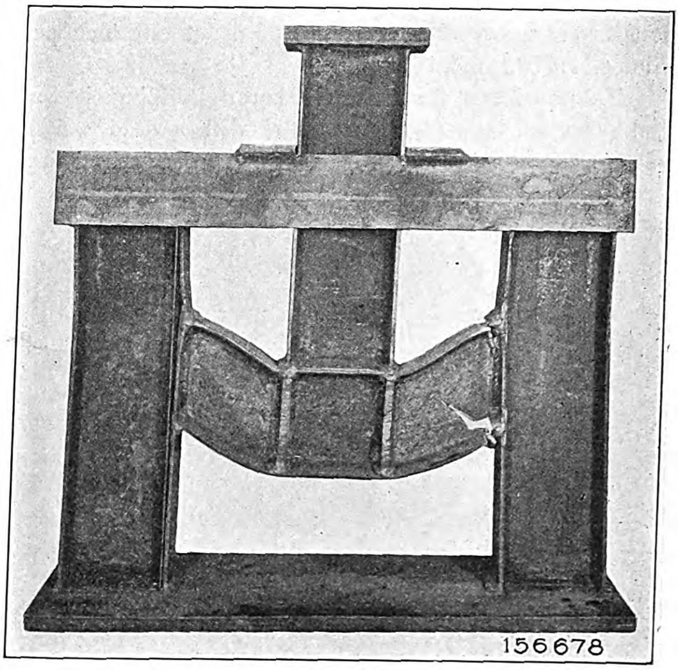






All of the above girders were tested by central loading on a bearing plate 1½"x5"x8" long placed lengthwise across the top flange of the beam.

To determine the effect of shock loads on arc welded members a structure as per Photo. 156500 was made up



near the center of each as possible by means of sharply pointed plumb bobs hung from the girder on the floor above. Deflection readings were obtained at the load increments shown in the table below by means of an accurately calibrated wedge block under each bob.

The deflections at the maximum load of 82900 lbs. was about 0.44″ for the outside girder framing into the outside wall column and exactly 0.25″ for the inside girder. These girders are 20″ I 65 lb. When the load was removed the girders both came back up to within 0.006″ of the initial no load readings of the plumb bobs. This test would have wrecked standard riveted connections and completely establishes that continuity is obtained.

Calculations have shown the load fibre stress to be between 32000 and 33000 lbs. per square inch whereas the building design is based upon 18000 lbs. per sq. in., the girders and columns being designed on the basis of 200 lbs. floor load, but floor beams for 300 lbs. floor load to provide for special concentrations and suddenly applied loads.

In view of the excellent results obtained from this pair of girders picked at random and due to the expense involved in cutting through flooring, etc., it was deemed inadvisable to test additional points.

Center Load in Lbs.	Deflection in Inches at 6 Plumb Bobs					
	1	2	3	4	5	6
25100	.019	.095	.011	.070	.127	.089
50300	.086	.194	.051	.137	.260	.172
75400	.146	.222	.095	.210	.400	.273
82900	.171	.250	.111	.250	.442	.324
	Distance in Feet From Second Interior Column			Distance in Feet From First Interior Column		
	6	12.4	17.21	6	12.4	17.22

Summary

By perusal of the data which is given in his article it is manifest that the tests fully demonstrate the following facts:

(1) That arc welded joints can be constructed in such manner as to develop fully the ultimate strength of the structural members connected.

(2) Beams and girders can be connected to columns so as to produce absolute fixation.

(3) Lines of beams or girders can be connected so as to provide complete continuity across the supports, whether the supports be girders or columns.

(4) That a steel I beam of given section and length will sustain a far greater load if fixed at its ends by a suitably designed arc welded joint than if supported by standard riveted connections consisting of top and bottom angles. A 9 in. standard I beam framed between rigid upright columns 8 feet apart by means of specially designed welded connections sustained a load 25% greater than a beam of the same size and length framed between columns by means of riveted top and bottom angles of ½″ in thickness.

(5) A plate girder assembled by welding and consisting of nothing but sheared plates, has a far greater bending strength than a riveted plate and angle girder of the same weight, due to the better distribution of the steel in the cross section. A 15 in. plate girder assembled by welding and simply supported on a 14 ft. span developed more than 50% greater strength than a riveted plate and angle girder of the same depth and the same weight.

(6) A double angle tension member such as is used in trusses was connected at the ends by welding, and when tested to tension failure broke through the angles at a load 30% greater than the load at which a hanger consisting of the same size angles with riveted connections failed.

The prevailing impression among the witnesses was that these tests demonstrated the superiority of welded connections over riveted connections in every case where direct comparisons were made, and brought out two general facts:

(1) That complete continuity of lines of beams can be obtained in welded construction, whereas it is well known that this cannot be done in riveted construction.

(2) That in a welded building it will be possible to make every joint develop full strength of the main members, whereas in a riveted building many joints are weaker than the members due to the weakening effects of the rivet holes and the weakness of steel angles which have to be used for transmitting tension between two members at right angles to each other.

It was proved that a welded plate girder was 50% stronger than the riveted girder of relative depth, length and weight.

An Olsen testing machine, capable of applying 400,000 lbs. was used.

The tests proved the entire practicability of welding without any misgivings as to safety.

The joints as illustrated were used in the five story steel building, 70 x 220 ft., 80 ft. high, fabricated and erected by the American Bridge Company for the Sharon Works of the Westinghouse Electric & Mfg. Co. The typical beam and girder connections are fully continuous connections thereby permitting large percentage (about 12%) of saving in the weight of the beams and girders to carry a given load. The same type of connection which develops continuity also effectively stiffens the building against wind. The equivalent cannot be obtained by any known riveted joint.

The design of the test specimens described above, and the design for the welded steel building at Sharon, Pa., were produced by Mr. Gilbert D. Fish, Consulting Structural Steel Engineer, cooperating with the arc welding engineers of the Westinghouse Company. Complete data upon the physical properties of all of the steel, including tensile tests and chemical analyses were supplied, and great care was taken in selecting the steel material so that in so far as possible, it would be from the same heat so as to secure uniformity in comparing the various specimens.

Philadelphia's Bureau of Surveys[*]

Historical Data and Legislation Leading to the Establishment of the City Plan, Surveying of Property Lines; and the Bureau of Surveys in the City of Philadelphia

By J. HARVEY GILLINGHAM

THE City of Philadelphia is a part of the territory granted by Charter to William Penn in the early part of the year of 1682, by Charles the Second of England, and established by Proclamation of the King, April 2, 1682. The territory so granted is now the State of Pennsylvania.

The colonization of the territory was proceeding prior to the granting of the Charter, for on July 11, 1681, Penn provided in his conditions and concessions to first purchasers "That so soon as it pleaseth God that the above persons (his Commissioners) arrive there, a certain quantity of land or ground plot shall be laid out for a large town or city in the most convenient place upon the river for health and navigation; and every purchaser and adventurer shall, by lot, have so much land therein as will answer the proportion he hath bought or taken up upon rent."

Thomas Holme was Penn's first Surveyor General to act, and arrived in the Province in the latter part of June, 1682, and he must have proceeded immediately to lay out the town into building lots and assigning the lots to the purchasers.

A map was published in London, probably in 1683, with this title: "A portraiture of the City of Philadelphia in the Province of Pennsylvania in America, by Thomas Holme, Surveyor General." This map is the first known and provided a city of two square miles, or 1,280 acres—it included from the Delaware River to the Schuylkill River and from the present Vine street to South street, and is described by Thomas Holme in the following language—(City Solicitors Opinion 1891, page 91).

"The City of Philadelphia extends from river to river, two miles, and in breadth near a mile; and the Governor, as a further manifestation of his kindness unto the purchasers, hath freely given them their respective lots in the City, without defalcation of any of their quantities of purchased lands; and it is now placed and modeled between two rivers upon a neck of land; and that ships may ride in good anchorage in six or eight fathoms in both, close to the city, and the land of the city level, dry and wholesome, such a situation is scarce to be paralleled.

"The model of this city appears by a small draft made now, and may hereafter, when time permits, be augmented; and because there is not room to express the purchasers' names in the draft, I have therefore drawn directions of reference by way of numbers, whereby may be known each man's lot and place in the city. The city is so ordered by the Governor's care and prudence that it hath a front to each river, one-half at Delaware, the other at Schuylkill; and though all this cannot make way for small purchasers to be in the fronts, yet they are placed in the next street contiguous to each front, viz, all purchasers of one thousand acres and upwards have the front and the high street; and to every five thousand acres in the front, about an acre; and the smaller purchasers about half an acre in the backward streets; by which means the least hath room enough for house, garden and small orchard, to the great content and satisfaction of all here concerned.

"The city, as the model shows, consists of a large front street to each river, and a high street near the middle, from front or river to front, of one hundred feet broad, and a broad street in the middle of the city from side to side of the like breadth; in the center of the city, is a square of ten acres, at each angle are to be houses for public affairs, as a meeting house, assembly, or state house, market house, school house, and several other buildings for public concerns. There is also in each quarter of the city a square of eight acres, to be for the like uses as the Moorfields are in London; and eight streets besides the said high street, that runs from front to front, and twenty streets besides the broad street, that runs across the city from the one side to the other; all these streets are of fifty feet in breadth."

By an ordinance of May 9, 1804, the Mayor was authorized to appoint two qualified persons to survey and regulate that part of the city lying between Delaware Fifth street and the Schuylkill River, and directed that the street lines and grades be permanently marked by stones or marks upon the houses, also that a large and correct plan be made showing the principal streets, water courses and sewers, and that book of reference be made explaining all the principal features of the plan. This ordinance was supplemented by Ordinance of March 3, 1806, and June 8, 1807, which gave further instructions as to the marking of the street lines; the latter ordinance directed that the Surveyor "shall place the stones as directed by said ordinance within the limits of the front pavement and at a convenient and uniform distance from the true lines of the said principal streets respectively and at a convenient distance from the crossing and intersection thereof." In compliance with these ordinances there was made a careful survey and plan with the book of references, and signed by Reading Howell, March

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[*] Paper read May 26, 1927, before the Society of Municipal Engineers of Philadelphia.

15, 1809, and which are now on file in the Bureau of Surveys.

An ordinance of July 13, 1809, refers to the completion of the plan and book and provides "That the surveyors of the city and the city commissioners shall regulate the lines and limits of the streets, the ascents and descents thereof, courses of common sewers, within the limits aforesaid, and which have been surveyed in the manner aforesaid, agreeably to the said draft and books"—a penalty is also provided for disturbing any of the stones or marks set to designate the lines of the streets.

The plan shows the elevation of the curb at street intersections, summits and depressions, gradients between elevations, elevation of surface and location of water courses, location of stones set for the street lines and their elevations, references to buildings with relation to the street line but no block distances or street widths. This latter information, however, is contained in the Books of References.

This plan received official sanction by the Ordinance of 1809. Revisions of this plan have been made in part since consolidation, but for a large part of the area of the old city, which it covered, it still remains as the only Confirmed Plan. It is the first official city plan which approaches the Standard City Plan of present date, although similar plans had previously been made for the adjacent districts of Southwark and Northern Liberties, the former in 1790 and the latter in 1795 and 1799.

The City of Philadelphia continued in area as laid out by Thomas Holme until consolidation in 1854, but as the population grew it overflowed into surrounding territory—separate corporate districts were formed by the legislature for the government of their local affairs. Under Acts of Assembly of February 2, 1854, the City of Philadelphia and the surrounding districts and territory in the County of Philadelphia were consolidated, so that the limits of the City of Philadelphia and County of Philadelphia become coexistent and covered an area of approximately 130 square miles and nearly its present area.

This whole area is now covered by the present city plan of the street system. It consists of 239 sectional plans drawn to a scale of 100 feet to the inch, showing the present developed and projected street system into as yet undeveloped territory, with block distances accurately measured and calculated, street widths and subdivisions into footways and cartways, elevation of curb at street intersections and gradients, monumented by stones and references to buildings, bench marks referred to city datum, contours of the natural surface, courses by meridian of the streets and the angles formed, park area acquired, or proposed, or desired to be acquired.

In Philadelphia the city plan is enforcible by the Acts of 1871 and 1893, and these Acts are rarely intentionally violated. (See Act Dec. 27, 1871 and May 16, 1891.)

"It shall not be lawful to erect any building upon any of the streets laid out on the plans of the city, after said plans have been confirmed; and when said streets are ordered to be opened buildings erected upon them since their confirmation shall be removed at the expense of the owner, and without any damages being paid therefor."

"It was provided that 'no person shall hereafter be entitled to recover any damages for any buildings or improvements of any kind which shall or may be placed or constructed upon or within the lines of any located street or alley, after the same shall have been located or ordained by Councils.' "

The early surveying of the city was probably done by or under the direction of the Surveyor General of the Province, later by the surveyors and regulators, a title which still exists in the city and whose official duties are a most important function in the city government.

The earliest authority for the appointment of regulators in Philadelphia appears to be contained in an Act of May 10, 1698, which recited in part as follows: "Inasmuch as the ornament of towns and the convenience of the inhabitants so much depend upon the well regulating of streets and landing places, and that the said landings, streets and water courses therein may be effectually regulated and repaired; Be it enacted by the authorities aforesaid that the Governor with four of the Council from time to time shall nominate and appoint such and so many as they may think needful of the substantial inhabitants of the towns respectively when there may be occasion to regulate the said streets and water courses and to order pitching, paving and grading thereof."

In pursuance of this Act there is record that regulators were appointed in 1699 and 1701 by the Governor, with consent of the Provincial Council, and subsequently by the Mayor and Aldermen in 1713 and 1717.

An Act providing for the regulating of party walls and buildings and partition fences, passed by the Assembly February 24, 1721, is quoted in part as follows: "Be it enacted; That no person nor persons, builder or builders, whatsoever, shall lay the foundation of any building or party wall within the said city before they have applied themselves to the surveyors or regulators.

Section 2. The surveyors and regulators upon application shall have full power and authority to enter upon the land of any person or persons in order to set out the foundations and regulate the walls to be built between party and party as to the breadth and thickness thereof; which such party wall is made; and the first builder shall be reimbursed one moiety of the charge of said wall, or for so much therefore as the next builder has occasion to make use of, before such next builder shall any wise use or break into said wall, The charge or value thereof to be set by the said regulators."

This Act is still law in operation and is the basic authority for the official determination of party lines by the surveyors and regulators.

Surveyors and regulators had been elected or appointed in all the outlying districts surrounding the city from the time of their incorporation until the consolidation, and the legislation and duties relating thereto had been practically the same throughout the whole County of Philadelphia.

The Board of Surveyors was created under the Consolidation Act of February 2, 1854, which provided that the Councils of said city shall appoint a competent number of skillful surveyors and regulators and such number shall be organized into a board under a head for such purposes relating to surveys, and planning of the city, the building of bridges, the construction of sewers and grading of highways, as councils may declare by ordinance. This Act was amended April 21, 1855, and divided the city into twelve Survey Districts and provided for the elections of the Surveyors and Regulators by the people residing in the Districts.

A further amendment of May 13, 1856, to the Consolidation Act prescribed the qualifications of the Chief Engineer and the District Surveyors. Councils acting under authority of this law, by ordinance of June 20, 1863, organized the Department of Surveys.

The power to confirm the City plan was vested by the Acts of Consolidation in the Court of Quarter Sessions until 1871, when by an Act of Assembly of June 6, 1871, this power was vested in the Board of Surveyors.

The legislation herein referred to is still in force so far as it relates to the duties and powers of the Department of Surveys, the Board of Surveyors and the Surveyors and Regulators.

By the Charter Acts of June 1, 1885 and June 25, 1919, the Department of Surveys was attached to the Department of Public Works as the Bureau of Surveys, with the power of the Board of Surveyors and the Surveyors and Regulators retained. All the officers and employees are appointed by the Director of Public Works under civil service regulations—all fees formerly collected by the surveyors and regulators are paid into the City Treasury.

On January 1, 1925, all work of construction relating to sewers, bridges and abolishment of grade crossings was transferred to a new bureau created as the Bureau of Engineering, and the Bureau of Surveys retained all matters pertaining to the planning and confirmation of plans of the street system, and approval of deeds of dedication of streets, the approval of plans for the construction and relocation of street railway tracks, and subdivision of property for building purposes, through the Board of Surveyors. The surveying and determination of all property and street lines for building and conveyances, the giving of lines and grades, and the certification of the work performed for the construction of sewers and bridges, curbing, grading, paving and macadamizing, under private and municipal contracts in the Bureau of Construction, the assessment against the owners of property for all classes of municipal improvements—plans and estimates preliminary to contracts for the above work, plans for the Department of Law for the opening, widening and change of grade of streets and all other matters wherein the city plan is involved, through the Surveyors and Regulators; the filing of the city plan, deeds of dedication of streets and other information relating to the legal opening of streets, and the registration of all subdivisions and transfers of property through the Registry Bureau.

The Registry Division of the Bureau of Surveys is a very important adjunct of the recording system in Philadelphia of the land sub-division of the City plan. It is a graphical index of the dimensions of all the properties in the City and of the latest recorded owners of the property.

From the information contained in the books of this bureau, the Board of Assessors make up the assessment for all city property, and the legal opening of streets is set forth in such a way as to readily indicate how the street became opened.

This bureau was organized under the Act of March 8, 1862, and that Act directed that the books in the office of the Recorder of Deeds containing survey returns and descriptions of lots and tracts of land in the County of Philadelphia, be transferred to the office of the Department of Surveys, and authorized the Chief Engineer to have copies made of the original warrants and other documents in the Survey General's office in Harrisburg, and to procure from the office of the Clerk of the Quarter Sessions Court copies of all documents relating to the opening of all streets and roads in the county.

This Act also authorized the Chief Engineer and Surveyor to cause to be made books in sections showing ownership of all plots in the city, with provision for note of change in future ownership.

A later Act of March 14, 1865, made it compulsory upon all grantors or grantees of land to file with the Department of Surveys, a description of the land conveyed and provided a penalty for the omission of this duty.

The Act also provides that the Recorder of Deeds should not admit of record any conveyance, until such description had been filed with the Bureau. A supplement to this Act of March 29, 1868, provides that the Sheriff of the County of Philadelphia shall present the deeds of all properties sold at judicial sales, whether for petition or otherwise, for registration in the Bureau, and makes it a misdemeanor for admitting such deeds of record without such registration.

The Business Situation

PROSPERITY throughout the country is not uniform by any means and low rates of interest for borrowed capital is not going to offset the difficulty in maintaining satisfactory net earnings in many of the smaller industrial companies. The business of the country has not in the past faced exactly the same conditions and situations as at present exist. We have been enjoying prosperity which has been of a highly conservative nature and for that reason it is probable that it will continue at least throughout the coming five months of 1927.

The following quotations from the August letters of outstanding financial experts give their views on the situation:

The Guaranty Trust Co. of New York in its last issue of "The Guaranty Survey" write as follows:

"DEVELOPMENTS of the last few weeks tend to confirm the general view that the current recession in business activity is largely due to the seasonal influences that usually cause moderate curtailment at this time of year. Since 1923 the decline in general industrial operations and trade volumes between spring and summer has been so regular and so pronounced that many observers have hesitated to regard it as a purely seasonal swing. The suggestion has even been advanced that increased industrial plant capacities, larger credit resources, better transportation facilities and a modified distribution of income have combined to accelerate the response of business activity to changing conditions, so that the long and violent fluctuations that formerly constituted the so-called business cycle have, for the time being at least, been transformed into a series of semi-seasonal, semi-cyclical adjustments.

Financial Conditions Remain Strong

"Whether this view be accepted or not, it must be admitted that there are few factors in the present situation on which to base pessimistic views as to the near-term future of busines. Most of the conditions that might be mentioned as possible unfavorable influences, such as speculative activity in the security markets, large borrowings on security collateral, low earning power in coal, petroleum, copper and other industries, declining commodity prices, narrow profit margins in many branches of industry and trade and the unsettled state of international finance are not new developments, and in some cases show definite improvement during the recent past. On the other hand, it may be pointed out that domestic financial conditions remain strong, that operations in numerous industries are unusually well sustained and that the active movement of commodities in general into consumers' hands is distinctly encouraging.

Agriculture

"After an unusually discouraging start, the current crop season has assumed a much more favorable aspect during the last few weeks. Despite the handicaps imposed by the Mississippi floods and inclement weather in many other important farming sections in the early part of the year, the present condition of most of the leading crops is fairly good. Moreover, the outlook for farmers' earnings has been improved by the advance in prices of a number of products.

"The outlook for farm earnings this season has improved greatly with recent advances in prices of some of the leading products. In the last thirty days there have been further gains in prices of cotton, corn and livestock, while wheat prices, responding to the improvement in the corn crop prospect, have declined slightly.

"Another important factor in the agricultural situation, the significance of which has perhaps not been sufficiently appreciated, is the outlook for increased net returns to farmers with the progressive decline in costs of production due to improved methods. The use of agricultural machinery has increased very swiftly in the last decade, and it appears that this year's crops will be produced at the lowest average cost in many years. The influence of these improvements in technique is apparent also in the fact that the winter wheat crop is being marketed earlier than ever before. The reduction in costs due to modern methods of cultivation and harvesting may go far toward explaining the persistence of large crop acreages in the face of the price depression of recent years. Further extension of these improvements, together with increased co-operation and better marketing methods, will contribute largely to the ultimate solution of the agricultural problem."

The National City Bank of New York in the following extract from its August letter takes a very encouraging view of the situation:

THE general business situation has given evidence of no fundamental change during the past month. Taking trade and industry as a whole, the summer recession appears to have been no more than normal, despite such retarding influences as the recent floods, the soft coal strike, and reduced activities in the automobile industry. Volume and profits are by no means satisfactory in all lines, but enough good business seems assured to maintain the good record of 1927 to the end.

Measured by the volume of checks passing through the banks and by industrial consumption of electric power, business would appear to be running ahead of that of a year ago, while measured by factory employment and pay-rolls and by the railway movement of manufactured products it would appear to be running somewhat behind. Doubtless these divergencies are due to varying emphasis on different lines of trade, and their chief significance would seem to be in indicating the continuance of some unevenness in business, albeit that the average cannot be far from that of last year, which was of record volume.

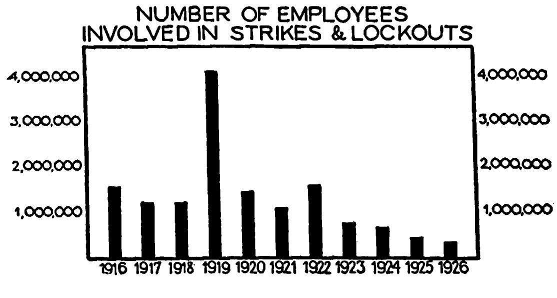
Oil companies, as expected, showed decreases in practically all cases, as compared with last year, due to the price cutting and over-production in that industry that is familiar to every one. Steel companies generally showed smaller earnings than last year, but the decline was less than might have been expected in view of the lower level of steel prices. Textile and leather concerns and a large number of companies in miscellaneous lines went ahead. Even the automobile industry, where particularly keen competitive conditions prevail, showed a number of very satisfactory gains, though it is doubtful whether, if statements for all companies including Ford were available, the aggregate totals would measure up to those of last year.

When it is considered that last year was an unusually good year for business, success in maintaining anything like as favorable a showing this year in the face of increasing competition and further decline of prices in many lines, indicates a degree of efficiency on the part of business management which inspires confidence in the maintenance of stability.

Employment Conditions Good

Employment conditions throughout the country continue generally satisfactory. Jobs are a little harder to get than in the past, which has been an added incentive to efficiency on the part of those holding them, but outside of the union coal regions and the automobile industry at Detroit, no widespread unemployment exists.

Contrasting with the troubled social conditions in many other parts of the world, our own country presents a picture of industrial peace which is striking. Due to the high wages paid, our present prosperity has been unusually devoid of the labor difficulties which ordinarily accompany periods of high pressure business activity. With the exception of the soft coal strike, the United States has not had a major labor tieup this year, and records of the Department of Labor show that last year, despite the anthracite coal strike, the number of workers involved in strikes and lockouts was the smallest in over ten years. The diagram, showing these figures each year since 1916 reflects clearly the improved relations that have come to exist between labor and capital during the past few years:



Industry can take satisfaction in these figures, but should not forget that high wages alone do not create prosperity. Only when they are accompanied and supported by increased production do they become the basis for sound business progress.

Dun's Review recently carried the following:

JULY is closing with more activity in some quarters, and with more firmness in commodity prices, than appeared when the month opened. Midsummer gains in business have a special interest, for they are rather unusual, except in lines that are stimulated by purely seasonal influences. The expansion now is mainly moderate and is by no means widespread, yet the progressive upward trend in certain of the principal trades is a constructive development.

Increased dealing in textiles, especially in the cotton goods division, indicate that some buyers' stocks are running low, while the improvement in leather conditions is reflected both in a larger demand and advanced prices. Such change as has occurred in the great steel industry, moreover, has been in the direction of betterment, and it is significant in this connection that farm implement makers have been more active in the markets and that building operations are holding at a higher level than was commonly anticipated.

The general business situation now, as it has been for a long time, is marked by sharp irregularities and contrasts, but it is hardly to be expected that favorable phases will prevail simultaneously in all channels. There is an over-production in some instances, competition for orders nearly everywhere is exceptionally keen, with a consequent narrowing of profit margins, and the practice of purchasing in relatively small lots and chiefly for current and nearby needs, is being rigidly adhered to. Yet that policy, if causing difficulty in arranging manufacturing schedules, tends to minimize the possibilities of a sudden reaction, inventories being kept within conservative limits. As was clearly foreshadowed, financial statements for the second quarter and for the half year show somewhat widely varying results, but the reports of the leading units in the steel and automobile industries are highly satisfactory. In response to these bullish exhibits, and also because of a maintenance of low money rates, the buoyancy of the stock market has become still more pronounced. With a more promising outlook for crops and with a sustained large consumption of merchandise, prospects for Autumn trade are viewed with confidence in most circles and in parts of the West sentiment has strengthened noticeably.

Items of Interest

Atomic Hydrogen Welding Is Now Made Practicable

Atomic hydrogen welding—the process by means of which hitherto unweldable metals can be melted and fused without the slightest trace of oxidation, and welding can be performed in some cases on metals as thin as the paper on which this is printed—is now made practicable by the use of equipment recently placed on the market. This process, making possible the welding of many special alloys and the production of ductile welds in iron and steel, is the result of research conducted by Dr. Irving Langmuir, of the General Electric research laboratory.

In brief, this method utilizes the passage of a stream of hydrogen through the arc between two electrodes. The heat of the arc breaks up the hydrogen molecules into atoms. These combine again a short distance beyond the arc into molecules of the gas, and in so doing liberate an enormous amount of heat, so that more effective welding temperatures can be obtained than with the usual welding methods.

Since atomic hydrogen is a powerful reducing agent, it reduces any oxides which might other wise form on the surface of the metal. Alloys containing chromium, aluminum, silicon or manganese can thus be welded without fluxes and without surface oxidation.

Thorough trials, extending over a period of many months, were made and the apparatus, as finally designed, represents the result of continued experimentation and research.

The welding outfit consists of the following: (1) a single-phase transformer for converting the voltage of a 60-cycle source of power to one suitable for the welding equipment; (2) a specially designed, variable reactor to provide the proper welding current and voltage for different classes of work, and (3) the welding torch by means of which the actual work of welding is performed.

While the principle of operation is the same as that involved in the design announced by the General Electric research laboratory a year ago, the mechanical and electrical design has been much improved. The torch consists of a holder supporting two tungsten wire electrodes, the electric conductors connecting these electrodes through the reactor to the supply source, and the tubing for the hydrogen gas. Each electrode is supported inside a nozzle through which the hydrogen gas is forced out around the electrode. The combination of electrodes and nozzles is set at an angle and the distance between electrodes, or arc length, and also the flow of gas, are readily adjustable.

The electric conductors to and through the torch are heavily insulated and, when welding ceases, the welding circuit is automatically interrupted until such time as the operator is ready to weld again, when the circuit is automatically restored. In contrast to the usual method of electric arc welding, there is no current flowing from the electrodes to the work to be welded. The circuit is completed from one electrode to the other.

The reactor consists of a "U"-shaped core provided with pole faces between which a pivoted armature is arranged to move. The legs of the core are provided with coils connected in series with the electrodes of the welding torch. The amount of welding current and voltage is governed by the movable armature which changes the air gap of the magnetic circuit and therefore the reactance. This armature is normally biased to an open position, and, upon a flow of current through the coils of the reactor, is attracted to a closed position that may be determined by means of a handle and a suitable mechanism. When the arc is struck the armature automatically assumes the closed position and remains there until welding ceases, when it automatically resumes the normal position of maximum air gap.

In making edge welds, the metal to be welded is melted under the heat of the arc, but for that type of welding it is necessary to add additional metal from a filler rod fed into the arc in much the same manner as is followed in the ordinary gas welding process.

The new equipment is so far being marketed for operation from 60-cycle, single-phase circuits only, and is recommended for use on ordinary metals of less than ¼ inch in thickness, or on hitherto unweldable metals of greater thickness. Metals having a thickness of but 10 mils can easily be welded and little doubt is expressed that, in some cases, work as thin as 2 mils (about the thickness of ordinary writing paper) can be welded.

Because of the absence of oxides and nitrides from the weld made by this process, it is particularly adaptable to the welding of special alloys so far not weldable by other methods, and also makes a strong, smooth and ductile weld on ordinary iron and steel work. Inasmuch as pure chromium, nickel, copper, aluminum, silver and other metals and their alloys—not to mention iron and the more common metals—can be melted without oxidation, it is expected that new possibilities will be opened in such welding, although the field of application has been but partly studied.

Gas Engineers Will Show Coal Is a Raw Material, Not Fuel

Leading gas engineers are setting about to disprove what has long been considered an almost axiomatic theory, that coal is fuel, according to a recent report of the American Gas Association. The contention is that coal, which must for thousands of years remain the chief energy resource of the world, is an essential raw material from the social, scientific and industrial viewpoints.

These engineers feel that but a relatively few years will elapse before their ideas are proved. Basing their conclusions on the fact that from 1815 to 1914 the white population of the world increased three-fold, while the production of mineral fuels, coal, oil, and natural gas, increased seventy-five times, they foresee a rapid culmination of the theory that the burning of raw coal defeats conservation, and at the same time is uneconomic and injurious to health.

"Giant gas plants situated at strategic points throughout the country where coal is easily available, and a network of gas mains distributing clean gas at high pressures over long distances is an accomplishment of the future," says their report. "Already sufficient knowledge is at hand to prove the practicability of this endeavor. Two gas mains from Ohio to West Virginia, 300 miles long, distribute natural gas at relatively high pressure.

"Another natural gas line, now under way, will be 450 miles long, and will pass gas at 450 pounds pressure."

The situation in the Ruhr district in Germany is especially bright, these engineers feel. Throughout the great iron and coal district of the Ruhr, there are enormous coke-oven systems, resulting in the production of huge quantities of coke-oven gas. The proposed method of utilizing this gas, which is a by-product of the coke ovens, is to construct a main 450 miles long to transmit gas at 450 pounds pressure. The gas would be piped to the local gas companies serving towns and cities far away.

"While the German situation is comparable to that in certain sections of America, a furtherance of the idea will prove to be much more practical," it is claimed. "The erection of giant gas manufacturing plants, at the mine mouth, or at strategic points, will take the place of the German coke ovens. The coke that is made will then be utilized in the making of additional gas, by a process that has been proved economically sound for many years, with the result that these plants will be able to pipe large quantities of gas to the surrounding territories.

"There will be absolutely no waste attached to these huge gas plants. The utilization of the coke for additional gas-making will solve the problem of its disposal in sections where there are huge batteries of coke ovens today. The other by-products of gas manufacture can be disposed of easily. These include valuable fertilizers, perfumes, tar, etc."

The gradual exhaustion of the natural gas supply is a stimulus to the development of huge gas plants, the report continues. Already research is underway at the American Gas Association Testing Laboratory to determine the most economic means of mixing manufactured with the natural product.

Local Government Expenditures

More than half a billion dollars, or more than one-tenth of the total of expenditures of local governments in the United States represents waste, and could be saved each year without diminution, either in quality or quantity, of governmental services now rendered, according to the National Industrial Conference Board. The Conference Board gives this figure as its minimum estimate of the amount of the public's money which is dissipated annually through faulty government organization, lack of co-ordination, inefficient budget policies and, in some cases, sheer extravagance.

There are about three-quarters of a million separate local taxing and spending units in the United States, which operate independently and whose aggregate expenditures have risen from $1,844,000,000 in 1913 to $5,829,000,000 in 1925, or from $19.10 to $50.52 per capita of population. Constitutional or statutory restrictions on tax rates or the amount of bonded indebtedness that may be incurred, have frequently proved ineffective. Where the tax rates alone are restricted by law, the law often is nullified by increasing the bonded indebtedness; where both bonded indebtedness and tax rates are limited, increase in floating indebtedness has been resorted to. Definite results, however, have been achieved where the details of tax levying and borrowing, and in some cases even of expenditures, are subject to the supervision and control of central bodies; such as county boards in Oregon, Oklahoma and Ohio, or state commissions, as in Indiana, New Mexico and Massachusetts.

Such centralized control of city, town, county, village, school district, park district and other local government finances, already the object of experimentation in a number of states, is the most significant development in the evolution of a general policy for regulating and integrating the heretofore largely haphazard procedure of raising and spending public funds. The Board bases its belief on the results of detailed studies of the fiscal problems in a number of individual states, particularly those of New Mexico, Indiana, California, Illinois, Delaware and New York. Wherever such detailed studies are made in states which have no system of centralized control—and most of the states have not—it is found that millions can be saved annually by better organization and improved budget policies without curtailment of the functions or services rendered by the respective governments.

Nickel Steel Data and Applications

Copies of any of the following Bulletins will be mailed upon receipt of request sent to ENGINEERS AND ENGINEERING:

Bulletin No. 1—
  Society of Automotive Engineers.
  Standard Specifications for Steels.
Bulletin No. 2—
  Physical and Mechanical Properties of Nickel Steels.
Bulletin No. 3—
  Heat Treatment and Application of Nickel and Nickel Chromium Steels.
Bulletin No. 4—
  Making Steel Castings Stronger.
Bulletin No. 5—
  The Mill Inspection of Steel.
Bulletin No. 6—
  Alloy Steel Reduces Die Block Costs.
Bulletin No. 7—
  Automobile Design and Automotive Steels.
Bulletin No. 8—
  Improving Gray Cast Iron with Nickel.
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  Physical Properties of Nickel and Nickel Chromium Steels.
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The Stadia Circle

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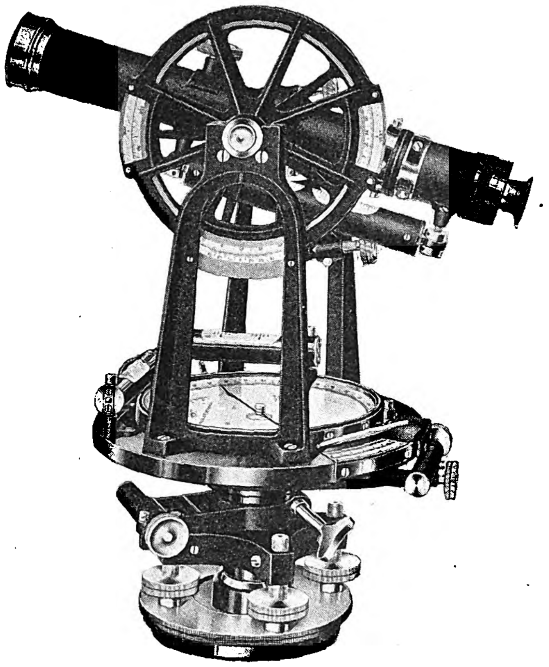
The Stadia Circle does not add weight or bulk to the instrument; is read as easily as any simple measuring device; and the readings require no qualifications upon the part of the instrumentman before they are recorded.



Highway Bridge Location

The various factors which influence the selection of locations for highway bridges are discussed in Department Bulletin 1486-D, by C. B. McCullough, bridge engineer, Oregon State Highway Commission.

The bulletin discusses the location of minor bridge structures, cost considerations involved in the location of large structures, maintenance considerations affecting bridge location, alignment, grade-line treatments, traffic influence on bridge location, and location over navigable waters.

Copies of the bulletin may be obtained, as long as the supply lasts, by writing to the United States Department of Agriculture, Washington, D. C.

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"Valuation, Depreciation and the Rate-Base" is a book to be owned by every engineer, actuary, banker, business man, and appraiser. Not only is this volume necessary to the professional man, but it contains information which will be invaluable to the student. The purpose of this book is to discuss the various problems connected with the Valuation of property, principally that of public utilities; the proper method of treating Depreciation; and the determination of a Rate-Base which will be equitable to the public and yield a reasonable return to the owner. Fluctuating conditions test the methods, now in use for evaluating property. In some recent instances, valuations have been materially affected due to abnormal conditions, and the need for standardization.

There is a scarcity of definite available material on the subject of Valuation, Depreciation and the Rate-Base. The authors have collected the best tabular material on the topics covered in their book with full explanations of the underlying formulae. They have had many opportunities to study the valuation problem from personal contacts and long experience.

Time & Motion Study & Formulas for Wage Incentives, by Stewart M. Lowry, Assistant Superintendent, International Derrick and Equipment Co., Harold B. Maynard, Supervisor, Manufacturing Operations Department, Westinghouse Electric and Manufacturing Co., and G. J. Stegemerten, Supervisor, Time-Study Department, Westinghouse Electric and Manufacturing Co. 377 pages, 6x9, 67 illustrations. $4.00.

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Management and Methods in Concrete Highway Construction—By J. L. Harrison, Highway Engineer, U. S. Bureau of Public Roads. 242 pages, 6x9, 74 illustrations. $3.00.

An exhaustive discussion of the management of production and the use of appropriate production methods in concrete highway construction. A book that shows how to reconcile superior work and adequate profit. A treatment from the standpoint of the man who actually builds roads.

Fatigue of Metals—By H. F. Moore, Research Professor of Engineering Materials, University of Illinois; in Charge, Joint Investigation of the Fatigue of Metals, and J. B. Kommers, Associate Professor of Mechanics, University of Wisconsin, Formerly Engineer of Tests, Joint Investigation of the Fatigue of Metals. 326 pages, 6x9, 102 illustrations. $4.00.

A summary of the more important experimental facts concerning the strength of metals under repeated stress; a brief review of the more important of the current theories of fatigue of metals and a description of apparatus and methods used in making an experimental study of the fatigue of metals.

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Explains the theory and constructions of charts and the practical application of certain mathematical principles.

The Ore Magmas—By J. E. Spurr, Editor, Engineers and Mining Journal Press. Two volumes. 915 pages, 6x9, 175 illustrations. $8.00 per set.

Mr. Spurr is well known through his numerous contributions to the science of economic geology. In 1898 he proposed the theory of the origin of certain gold-quartz veins by "magmatic differentiation." In 1907 he proposed the Zonal Theory of metallic ore deposition. These theories have become widely accepted.

The present volumes propose other new and almost startling conceptions of ore depositions, so far do they differ from those currently accepted. Among these is the conclusion of the injection of many mineral veins as a dense solution or gelatinous mass, very much as igneous dikes are injected; the conclusion that these ore fluids, or ore magmas, as the author calls them, belong to the class of true magmas, and not magmatic waters, as has been universally conceived; and that ores may lie in great, definite, straight, persistent belts which have no relation to folding and faulting, and other phenomena of the earth's crust, being of deeper origin.

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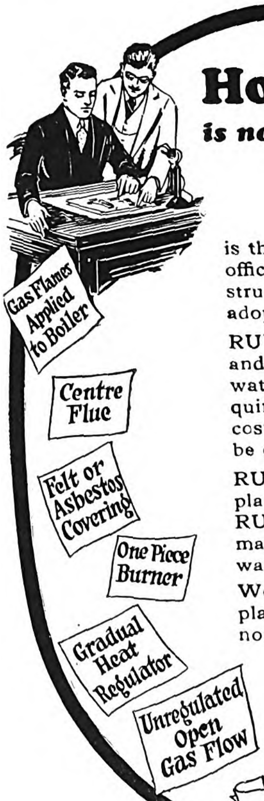
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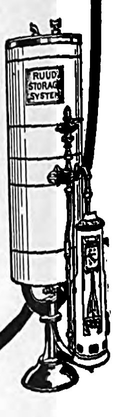

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DRAFTSMEN AND DESIGNERS. Prefer those experienced in auto body die work. Also good draftsman with tool, jig and fixture experience. Box E-1374.

CONSTRUCTION ENGINEERS, junior construction engineers, mechanical and electrical engineers and structural and reinforced concrete draftsmen should get in touch with Engineers and Engineering Employment Bureau. We have requests at present for several such men.

MEN AVAILABLE:

SALES ENGINEER, age 37, graduate mechanical engineer, eight years' experience in the sale of power plant, pumping and other machinery. Box A-1007.

RECENT GRADUATE, C. E., summer experience in survey, reinforced concrete building construction and concrete road work, desires position with consulting engineer or one leading to design of reinforced concrete or sales engineer. Box A-1008.

MECHANICAL ENGINEER, age 37, 14 years' experience in industrial plant maintenance and construction, desires position in or near Philadelphia. Salary $3,600. Box A-1009.

TOPOGRAPHIC SURVEYOR, 20 years' experience, all types surveys, hydrographic, topographic, railway, power line, right-of-way surveys, title examinations, involved boundaries, etc. Box A-1010.

SALES ENGINEER, 4 years' experience selling Public Utility companies, architects, consulting engineers and electrical contractors in eastern Pennsylvania, South Jersey and Delaware. Previously employed in Central Station design and construction work. Age 30. Married. Box A-1011.

SALES ENGINEER. Graduate E. E. Age 36. Ten years' experience selling jobbers, dealers, contractors handling specialties, etc. Any territory. Box A-1012.

SALES ENGINEER. Age 41. Married. With twenty years' design, construction, executive and sales experience, sales promotion of electro-mechanical equipment suitable to steel and iron industry, Public Utilities or Railroads. Box A-1013.

MECHANICAL SUPERINTENDENT, open for a position, desires to connect with a concern desiring the service of a live executive with 25 years' experience in the designing of tools and special machinery, shop maintenance and production. Age 45 years. Married. Box A-1014.

ELECTRICAL ENGINEER, graduate, 24 years old, wishes to secure position with a manufacturing or sales organization where there is opportunity for advancement. Box A-1015.

MECHANICAL ENGINEER, 17 years' experience, chief engineer or works manager. Thoroughly able and gets results. Write for full data even if no present opening. Box A-1016.

INDUSTRIAL ENGINEER, experienced in plant layout, routing and scheduling material, depreciation, industrial accident and fire prevention, and machine design, desires a position in or near Philadelphia. Best of references furnished. Box A-1017.

ELECTRICAL DESIGNER (Grad. E. E.). Twelve years' experience, desires connection with architect, consulting engineer or contractor, covering estimating, engineering and layout work in power and industrial plants. Box A-1018.

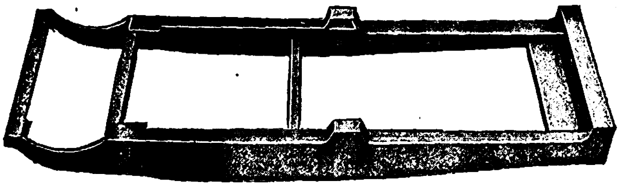
MECHANICAL AND ELECTRICAL ENGINEER, experienced in organizing and teaching in college of engineering, desires connection with commercial organization. Would consider management, or assistant to department manager, operation, sales. Box A-1019.

MECHANICAL ENGINEER (Graduate U. of P. and Carnegie Tech.). Production, design of automotive gasoline, oil engines, tools, punches, dies, jigs and fixtures, with thorough shop experience, desires connection. Box A-1020.

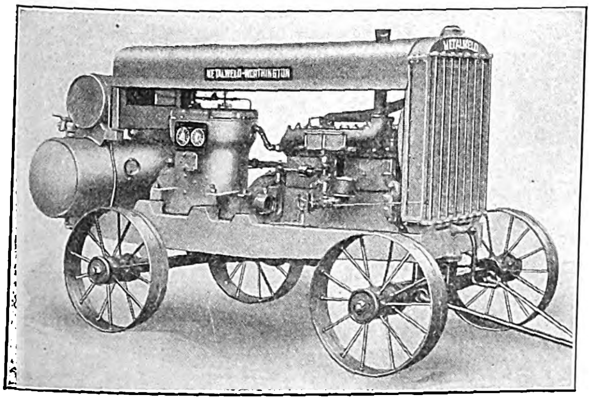
REG. PROF. CIVIL ENGINEER and Land Surveyor desires connection where 18 years' varied organization, design and construction experience will be of value. Capable of responsible charge and executive requirements. Experience in organization studies, analysis and reports. Interested in sales engineering where knowledge of construction materials and personality would be an asset. Box A-1021.

MECHANICAL AND ELECTRICAL ENGINEER

Note The Frame Construction.



Type of frame used on all **Metalweld-Worthington** portable air compressors. Note heavy cross members and engine supports, insuring minimum vibration and great rigidity.



110 cubic foot **Metalweld-Worthington** portable compressor with Continental Red Seal Engine.

The frames on all

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Portable Air Compressors

are of all steel construction, Electrically Lock welded.

Frames of this design will withstand the rough usage that portable compressors are subjected to and are far superior to either cast steel or riveted frames.

These compressor units are manufactured in 110 cu. ft. and 210 cu. ft. sizes in both gasoline engine and electric motor driven types. Send for specification sheet.

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wishes position in drafting room requiring experience in machine design, power plant design, piping or heating layouts, or electrical installations, large or small. Box A-1022.

MECHANICAL ENGINEER, experienced in design, planning, processing and supervision of production of interchangeable parts; tools and equipment for automobiles, all metal airplane wings, rubber products, etc. Box A-1023.

GRADUATE STRUCTURAL ENGINEER, has been handling all office detail and some outside supervision of Philadelphia concern for last five years, would like to connect with local concern. Experienced in foundation and grading, estimating and supervision. Box A-1024.

STRUCTURAL ENGINEER. Graduate Drexel Institute, 1924, in Civil Engineering. Desires work of any kind in construction line, preferably structural steel design or detailing. Box A-1025.

MECHANICAL ENGINEER, technical graduate, with 30 years' experience in designing piping systems, power station arrangements, conveying machinery, track layouts, structural steel, analysis of stresses, ship structure and details. Also experienced in land surveying and estimating labor and material costs. Box A-1026.

YOUNG MAN, 22, with 2 years' survey work. Assistant engineer and making tests for architectural engineer, 3 years' practical mechanical drawing. With initiative and willingness, desires field work of any kind. Box A-1027.

CIVIL AND HYDRAULIC ENGINEER, English, aged 38. Experienced in Hydro-Electric work. Good grounding in French and Spanish, desires position in Spanish America or Canada. Excellent references. Box A-1028.

DESIGNER-EXECUTIVE. Having 16 years' varied experience many types of machine design, hydraulic machinery, plant maintenance, layout and extension, structural steel. Eight years in charge, now so engaged; for excellent reasons desires change. Available in September. Age 38, married, possesses initiative, executive ability. Box A-1029.

DEVELOPMENT ENGINEER, creative design, technical education. Thirteen years' mechanical experience, desires work along machine design and development lines. Box A-1030.

DESIGNER of machinery and special tools, a specialty. Let me submit my varied experiences. Box A-1031.

YOUNG MAN, in 21st year, taking civil course in Drexel evening school, desires work with engineer or contractor, either inside or outside work. Two years' drafting experience. Box A-1032.

CIVIL ENGINEER, age 24, single, graduate civil engineering, 1925, from Univ. of Penna., 2 years' experience as structural detailer, designer and estimator. Desires position on construction work, surveying, laying out work and inspection. Available two weeks after notice. Box A-1033.

ELECTRICAL ENGINEER, Drexel graduate, 5 years' experience in power construction, estimating and designing. Desires position with reliable firm of engineers, either electrical or consulting. Will consider sales work. Box A-1034.

SALES POSITION for power plant or heating and ventilating apparatus in eastern section of country. Location: Philadelphia, Washington or New York City. Eight years in engineering sales. Box A-1035.

SALESMAN desires position, thoroughly familiar with steam specialties for power plants, high and low pressure piping, high temperature cements and insulation. Temperature control and boilers, tanks and stacks. Can furnish first-class references. Box A-1036.

WORKS MANAGER OR ASSISTANT. Experienced in large production machine and piers work, responsible for overhead, costs, inventory turnovers, purchasing, planning, tools, etc. Box A-1037.

SALES EXECUTIVE. Sixteen years' successful selling and sales executive experience in mechanical, electrical and steel lines. Services now available, for company not satisfied with their present sales conditions. Box A-1038.

DRAFTSMAN. Structural detailer, steel plate design, tanks, building. Five years' experience, 3 years Drexel Institute, references and samples of work submitted. Box A-1039.

ELECTRICAL ENGINEER. Graduate of University of Pennsylvania, 12 years' experience including power plant design, railway projects, industrial engineering and engineering management. Available on reasonable notice. Box A-1040.

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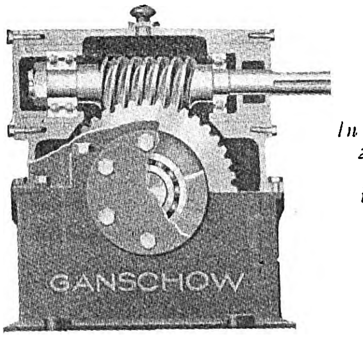

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ENGINEERS & ENGINEERING

SEPTEMBER, 1927

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Vol. XLIV No. 9

The Place of the Local Engineering Society in the National Standardization Movement

By CHARLES E. SKINNER
Chairman, American Engineering Standards Committee

THE whole industrial fabric of the United States has become so interlinked and so interconnected that no industry or manufacturing unit is independent of others. This dependency extends all the way from the group that secures the raw material from its original sources, through all the stages of manufacture, to the ultimate user. The finished product of one group becomes the raw material of the next. Each manufacturer deals with a large number of sources of supply for his raw materials and usually places his finished product in a large number of more or less related groups. The requirements of related and unrelated groups bring about a constant tendency to increase the varieties of products, usually based on either real or fancied differences in needs, but often due merely to the idiosyncrasies of some individual or group with the idea that such special requirements give them either a commercial or engineering advantage. These general conditions have brought about a multitude of varieties, types and sizes in practically every industry of the country. The reduction of these types, sizes and varieties to a point which permits manufacture in quantity must be brought about through simplification and standardization.

A study of group requirements usually reveals the fact that the differences developed through individual initiative can readily be harmonized so that a given material or given form can be made applicable for the major part of the industries using it. Many manufacturers in common started the work of simplification and standardization within their own organizations. Technical societies found that a program of standardization was a major service to their constituents. As trade associations arose, they found that a program of standardization was of utmost value in bringing about reduction in costs, uniformity in product, betterment in quality, and in making possible straight line loading and mass production.

All this has led to a multiplicity of the standards themselves, which has become more or less confusing, particularly in those groups where the work of the trade association more or less overlaps the work of the technical society in the same industry. To overcome this difficulty of overlapping effort and to provide for a co-ordinating group with authority to give the stamp of approval as "American Standard," the American Engineering Standards Committee was organized eight or nine years ago, primarily by the four so-called founder engineering societies and the American Society for Testing Materials. It soon developed, however, that a wider spread of interest and control was necessary if the American Engineering Standards Committee was adequately to carry out the objects its founders had in mind, and provision was made therefore, for membership in the A. E. S. C. by any national organization interested in engineering standardization. National engineering societies and trade associations have done much very valuable work in their own fields. A number of the United States Government Departments, particularly the Department of Commerce, the Department of Agriculture, and the War and Navy Departments, have also carried on standardization and the promulgation of standard specifications, especially for use by themselves and, latterly, through the Federal Specifications Board, a general plan for the unification of the requirements of all departments and bureaus of the Government has been inaugurated.

The American Engineering Standards Committee is a standards co-ordinating group with authority for the endorsement of nationally recognized standards as "American Standards" and embodying a scheme of sponsorships and sectional Committees so organized that new projects can be undertaken and carried through by group action when the standards in question are of major interest to a number of groups or organizations. The Committee has found itself in a new field of endeavor and, while it has accomplished much, both in the actual approval of standards and in the stimulation of the formulation of engineering standards and safety codes, much more remains to be done.

The multiplicity of standards-making agencies with overlapping authority resulting in certain delays and confusion and also the lack of sufficient financial support for the standardization program as a whole, have led to the formation of a Standardization Survey Committee, under the Chairmanship of the Honorable Herbert Hoover, which is undertaking to bring about a better co-ordination of standardizing agencies and a better support for them. During the last year or two, a very definite sentiment has developed to the effect that the standardization movement as a whole must have the unqualified backing of executives in industry if it is to score a major success, and it is fully to be expected that the work of the Standardization Survey Committee will be a factor in bringing to the attention of executives generally their responsibility in connection with this movement. One of the difficulties that have always existed, in connection with adopted standards, is the securing of widespread adherence to these standards by those who manufacture products covered by them. The Sectional Committee procedure of the A. E. S. C. is aimed at securing voluntary adherence to such standards by bringing in all parties at interest during the formation period so that the final standard as agreed to is "sold" when issued. This is, of necessity, a relatively slow process, and also of necessity, must be carried out by relatively few individuals, often representing a very large constituency. It is of primary importance that those affected by such standards become thoroughly familiar with them and, so far as may be possible, endeavor to follow them in the production of the manufactured goods and commodities which they affect. Local Engineering Societies can undoubtedly go far in helping to "sell" the nationally recognized standards. To do this, the advantages of the adoption of such standards, together with a thorough knowledge of the standards themselves, must be promulgated among the industries affected. This is a very large order and cannot be completely and successfully carried on by any central group. The efforts of the central group should be supplemented by local agencies, particularly in the manufacturing centers of the United States, and this can be done to advantage by just such groups as the Engineers Club of Philadelphia. A good start has been made through the efforts of Colonel Peck of Cleveland. The Cleveland Engineering Society, under his direction, have taken up enthusiastically the plan of "selling" standards to their local manufacturers. The Engineers' Society of Western Pennsylvania have organized a committee whose duty it shall be to forward this work in the Pittsburgh district. The Engineers' Club of Philadelphia can undoubtedly do much of value if it can secure the services of an enthusiastic and active committee to work with the local Philadelphia industries.

The American Engineering Standards Committee stands ready at any and all times to furnish all information and help in its power to back up all such local efforts. As Chairman of the Committee, I pledge its aid and help in any effort which the Engineers' Club of Philadelphia wishes to put forth.

Westward the Course of Industry Takes Its Way

In January, 1908, the center of industry in the United States was on the northern boundary of Indiana, about 110 miles east of Chicago. In January, 1918, it was still on the northern boundary of Indiana but had moved about 50 miles nearer to Chicago. In January, 1926, it had moved 25 miles to the southwest of its position in 1918 and was about 50 miles southeast of Chicago. The total movement in the 18 years from 1908 to 1926 was about 75 miles in a west by south direction. This slow movement of the center of industry during a period when the capacity of prime movers in central stations and manufacturing plants increased about 140 per cent indicates that industrial development in the United States is proceeding at about the same rate in all sections but a trifle more rapidly in the western and southern parts of the country.

These determinations of the center of industry, which have been made by the Geological Survey, Department of the Interior, are based on the capacity of steam engines, steam turbines, water wheels, and internal-combustion engines installed in manufacturing plants and in public-utility power plants. Twice the weight is given to the power equipment in public-utility power plants, as it is used twice as much as power equipment in manufacturing plants. Previous determinations of the center of industry have been based on the installed capacity of prime movers in manufacturing plants only. It is believed that more representative results are obtained by using the capacity of power equipment in both manufacturing and public-utility plants.

The geographic center of the United States is near the center of the northern boundary of Kansas, and the center of population is in Owen County, southwestern Indiana. The center of industry of the United States in 1926 was therefore 640 miles east by north of the geographic center and about 170 miles due north of the center of population.

Methods Used in Cleveland for Promoting American Engineering Standards

By T. F. GITHENS
Mechanical Engineer, Cleveland Twist Drill Company, Cleveland, Ohio

THIS paper will describe the things actually done in Cleveland to attract attention to American Standards, to maintain interest in them and to secure their practical application and use. A few examples showing the resulting economies due to the use of standardization are also given.

Cleveland Engineering Societies Standards Committee

The first thing done was to organize the Cleveland Engineering Society Standards Committee. The function of this committee was not to establish new standards but to "sell" to industry those approved by the A. E. S. C. It was a distributing agency, not a production one. This committee was organized by Col. E. C. Peck, who was formerly Chairman of the Standardization Committee of the American Society of Mechanical Engineers. Col. Peck directs the activities of the committee as chairman. There are on this committee with Col. Peck, George S. Case, Vice-President and General Manager, Lamson-Sessions Co. (Bolts and Nuts); W. J. Burger, Works Manager, Warner & Swasey Co. (Turret Lathes); G. T. Trundle, a consulting engineer, formerly Chief Engineer of the American Multigraph Co.; H. S. Kartsher, Standards Engineer, White Motor Co.; R. Rolf, Chief Engineer, Columbia Axle Co. (Automobiles); Y. R. Nelson, Production Engineer, Van Dorn & Dutton Gear Works; and T. F. Githens, Mechanical Engineer, Cleveland Twist Drill Co. The chart (fig. 1) shows how this committee is organized to serve local industries by promoting among them the knowledge and application of standards approved by the American Engineering Standards Committee. Squares represent men or organizations. Circles represent service.

General standards service comprised general publicity through newspapers, the Society Bulletins and by direct mail. The Society keeps on file for sale a complete set of the publications of the A. E. S. C. Quite a few have been sold in the district.

Each committee man is assigned a particular standard to "father." Up to the present, these standards have been limited to the Screw Thread, Pipe Thread and Metal Fits Standards.

The first plan for reaching the industries was to write a selected list of concerns the following letter:

"The Standards Committee of the Cleveland Engineering Society is attempting to acquaint the Manufacturers of the Cleveland District with the Standards already approved by the American Engineering Standards Committee.

"One well known man, high up in the industrial world, said, 'The adoption of the Standards now offered, will save a billion dollars.' We assume every manufacturer in the metal industry will want to know what these standards are doing for him."

"If you will send us the name of the man in your plant, responsible for promulgation of Standards, we will confer with him regarding the possibility of the approved standards being of use to your plant.

"He can then report his findings to you and in that way you will be in touch with the Standardization of the present time without having to give the details your personal attention.

"It is not the Committee's intention to try to force any Standards on you which are not economical or necessary.

"May we not hear from you by the return post-card, now?"

Very truly yours,
(Signed) E. C. PECK,
Chairman of the Cleveland Engineering
Standards Committee.

These letters were sent out about twelve at a time every two weeks, and the standards man's name in each plant, usually that of the chief engineer, was thus obtained. These men were then invited to a noon meeting of the Standards Committee and were "sold" on the Standards. About one hundred letters were sent out and approximately one-half the firms responded to this appeal.

Cleveland Engineering Society Standardization Practice Course

In order to reach those concerns that had not yet been "sold," a course was organized and successfully given. Both plant executives and men were reached. Instead of holding lectures at the Society rooms, it was thought it would be more interesting to take the men to several representative factories in the city and show by actual example how interchangeability and accuracy of fits were controlled. Accordingly, one afternoon and five evening inspection trips were arranged to manufacturing plants. Evening trips were scheduled because it was believed the men could attend them more conveniently than afternoon trips.

The chief advantage of the inspection trips to those attending the course was that they obtained in a first-hand manner practical concrete examples of the principles which the American Engineering Standards Committee is working for in a theoretical and general way.

During the month of January an exhibit of machine tools, small tools, gages and inspection instruments was in progress in the Cleveland Engineering Society's new exhibit rooms.

Lamson-Sessions Company

Mr. George S. Case, Vice-President and General Manager of the Lamson-Sessions Co., kindly offered the Kirk-Latty plant for the first inspection trip. Many clever automatic machines for the large scale production of bolts and screws of all sizes were seen. Thread rolling, thread cutting, and hot and cold heading machines of the latest and most advanced design were seen in operation.

After dinner in the cafeteria, Mr. Case, who is a member of the National Screw Thread Commission, explained how the quality of his product was maintained by the tolerance and gaging system recommended by the National Screw Thread Commission and American Engineering Standards Committee, and how the work of the thread standardizing committees was a big help to the bolt and nut industry by eliminating many special sizes. The American Standard Screw Threads Report was interestingly discussed and the importance of the establishment of tolerances for the screw and nut for Class 1 Loose Fit, Class 2 Free Fit, Class 3 Medium Fit and Class 4 Close Fit was brought out. For the first time now in the history of industry, manufacturers all over the country can make bolts and nuts that interchange universally. This was because of the establishment of the standard size minimum hole as basic, or as the zero or interference line below which no nut, and above which no screw (unless for tight fit) could go, because of the plus unilateral tolerance on the hole and the minus unilateral tolerance on the screw.

Cleveland Engineering Society Exhibit

The second meeting of the course was held in the Exhibit Room of the Cleveland Engineering Society. The speaker, Mr. E. J. Bryant, Manager of the Reamer and Gage Departments, Greenfield Tap & Die Co., Greenfield, Mass., gave a most interesting talk on the design, manufacture and use of thread gages, taps, dies and other tools for producing threads, to an audience of about one hundred fifty tool designers, manufacturers and production men. He also explained by means of charts how the screw thread fits, standardized as the American Standard Screw Thread, could be obtained with commercial taps and dies.

The American Standard Screw Threads report gives the fundamental definition of all terms used in discussing threads and their fits. The form of thread is described and illustrated; it is basically the U. S. Form of thread. There are two thread series, Coarse (U. S.) and Fine (SAE). There are four classes of fits—Loose, Free, Medium and Close. Tables are given containing the tolerances and allowances on nut and screw for major, pitch and minor diameters for each class of fit.

After the meeting, the tools on display in the exhibit room were inspected. Many of the exhibitors were present and took the opportunity to explain to interested groups the good qualities of their tools.

American Multigraph Company

The first evening plant inspection trip, the third meeting of the course, was held at the American Multigraph Company's plant. The men were divided into eight groups of about twelve each. The exhibits of the evening had been arranged on tables at eight stations, each in charge of one of the company's experienced men. After ten minutes at a station, each group moved to the next station in order and this was repeated until each group had spent ten minutes at each station. After the exhibit, the men were privileged to return to any station and ask questions.

This general plan was followed at each factory visited and proved very successful. The exhibits were usually arranged in stations in some large convenient room such as the cafeteria.

Cleveland Engineering Society Exhibit

The fourth meeting was held in the Exhibit Room of the Cleveland Engineering Society. A talk by Col. E. C. Peck, Chairman of the Standards Committee, was given on "The Standard Hole, Unilateral Tolerances and Measurements by Light Waves." He explained how the Standard Hole System allowed the use of standard reamers, taps and gages thus being the most economical system to use for interchangeable manufacture. He explained how Unilateral Tolerances, in connection with the Standard Hole, promoted universal interchangeability, a necessity in a time of emergency such as war and an economy at all times.

Special attention was called to the published "American Standard Tolerances, Allowances and Gages for Metal Fits," approved by the American Engineering Standards Committee, December, 1925. This report gives the fundamental principles of gaging, the process of measuring manufactured materials to assure the specified uniformity of size and contour required by the industries. Definitions of Standard Size, Nominal Size, Basic Size, Allowance, Tolerance and other terms used in interchangeable and selective assembly are given.

Eight classes of fits are described covering all desired conditions, Loose, Free, Medium, Snug, Wringing, Tight, Medium Force, Heavy Force and Shrink Fits.

Tolerances and allowances for establishing the limiting sizes of mating parts for interchangeable manufacture are given. Owing to the basic hole principle on which this report is based, shaft members made to the specifications of one class of fit may be mated with hole members made to the specifications of another class without destroying interchangeability.

Col. Peck also explained how light waves were used for checking gages to within a few millionths of an inch and gave demonstrations of the use of light waves projected and magnified upon a screen by means of a lantern. One interesting demonstration showed two steel rails bolted together with a spacer between. By squeezing them together, a deflection of a few millionths of an inch was easily observed on the screen, owing to the displacement of the interference bands obtained by the reflection of light from two correctly placed optical flats on the rails.

The Cleveland Twist Drill Company

The last meeting was held at the plant of the Cleveland Twist Drill Company. This meeting showed the use of drills and reamers in standardized production. There were eight stations through which the men were circulated after having been divided into groups as usual. These were:

1. Demonstration of correct and incorrect method of drill sharpening and the use of "Ezy Out" screw extractors.
2. Demonstrations of the use of small drills in brass, "Cleforge" drills in cast iron and of "Spirex" reamers in steel, showing the remarkable speed and quality obtained by the use of modern drills and reamers with powerful machinery.
3. Demonstration of large "Cleforge" drills in steel, showing ordinary speed for carbon drills, speed for high speed steel ten years ago, speed today and exhibition speed.
4. Demonstration of "Quick Set" reamers showing the interchangeability of blades and bodies.
5. Gages used to maintain interchangeability of shell reamers and arbors.
6. Exhibit of "Cleveland" tools.
7. Microscopic and Chemical Laboratories.
8. Steel Inspection Laboratory.

Conclusion

The taking of this course was of direct educational benefit to many of the men. They gained many ideas that were money makers in their everyday work by observing what others were doing in entirely different lines at each plant visited. The actual machine parts, fixtures, tools, gages and blueprints had been laid on the table and their meanings explained by experts. Knowledge of American Engineering Standards was carried in concentrated form to many concerns and to people who had paid but little attention to them previously. These standards are now used in many Cleveland shops.

The course was a direct benefit to the local and national distributers of high class manufacturing and precision tools. It relieved them of missionary work in convincing the user that accurate work on details is an economy, due to the savings in assembly and replacements.

There was a direct benefit to the community in general. The man who "knows how" can do work in half the time and of much better quality than the man who does not know how. This means less costly goods of the same or higher quality and this in turn means a rise in the standards of living; if everyone produces more with no increase in effort, simply an increase in knowledge and intelligence, everyone can consume more or enjoy a higher living standard.

Examples of the Benefit of Standardization

The Lamson-Sessions Company, manufacturers of bolts, nuts, rivets and cotters, have this to say:

"Standardization work has simplified many different phases of our work. In our mechanical and tool department, it has been our practice to standardize jigs, tools, tool holders, and even method of procedure in the manufacturing of tools. This enables us to always carry a minimum stock with rapid means of refilling. It is practically impossible for us to estimate this saving but the decrease in labor and production costs is considerable.

"Previously, each manufacturer was making his own standard article with his special type of thread. This has now been changed, so that most manufacturers' articles, are interchangeable in both size and fit. Standard gages have been adopted and this alone is a great factor with us. In fact today, standards are set on all processes in the manufacture of our product and we have found that the result is lower costs."

The White Motor Company, manufacturers of "White" motor trucks, report:

"As a general principle, we are strongly 'sold' on standardization. We suppose the strongest point we can make for it is that, without standardization, the White Motor Company or, in fact. the automotive industry, could not exist, as it is only by reason of a highly standardized condition that the present mass production is possible.

"In our own plant, by installing the A. E. S. C. Limit System, we have been able to do away with files and reamers on the assembly line, which we never thought would be possible.

"The adoption of the American Screw Thread Standard has released our screw machine load (formerly occupied by special screws) for other work, thereby eliminating the purchase of additional machinery.

"Our grinding wheel standardization work has made an annual reduction of $23,000 in that one item. And so we might continue giving numerous examples of savings due to standardization.

"The essential point is to organize for it. Standardization cannot be accomplished by slip-shod methods, but the expense involved will come back many times over in increased dividends."

The Cleveland Twist Drill Company reports that the standardization of the holes in shell reamers has been a source of saving to the users of these tools. Previous to this standardization, each of the fifteen shell reamer manufacturers had a different taper on the hole ranging from .1512 inch per foot to .096 inch per foot. Reamers of one manufacturer would not fit on the arbors of another. This was a source of annoyance, waste and expense. Now all taper holes are .125 inch per foot and reamers and arbors of all manufacturers are interchangeable. Standardization of reamer sizes on the standard basic fraction of an inch size means quick delivery from stock and economy in production of large lots.

The Columbia Axle Company reports that, by the application of standardization, their small tool inventory of reamers, drills, taps and gages was reduced from $60,000 to $24,000, or 60% in one year. Their pinion adjuster, for example, formerly called for a special thread. By making this thread standard, taps, dies and gages already in stock could be used and the others eliminated. Similar economies were effected in manufacturing numerous other parts.

Aviation Beacon Lights

The possibilities of the neon gas-filled lamp, with its pinkish glow and longer wave length, as an aviation beacon light with greater fog-penetrating range than the present type searchlights was demonstrated at Harrison, N. J., on June 10 by engineers of the Edison Lamp Works of the General Electric Company and the Cooper Hewitt Electric Company before a delegation from Washington consisting of representatives of the Army and Navy Departments, Bureau of Standards and Department of Commerce.

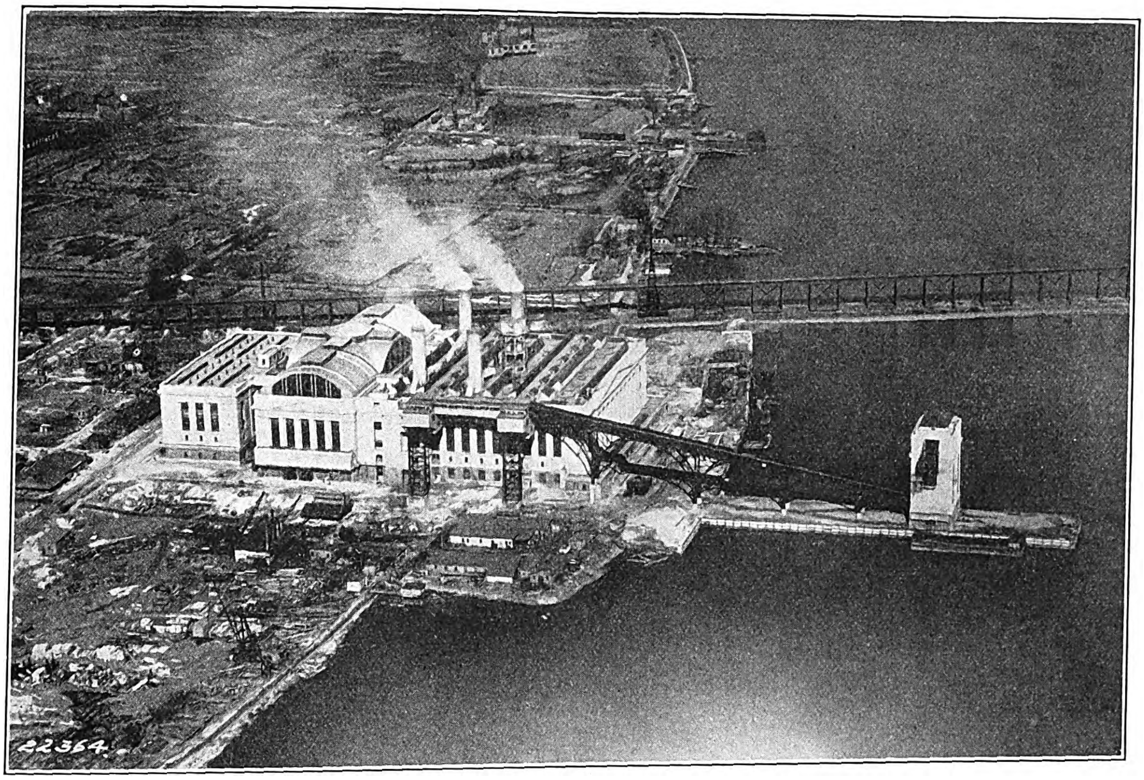
The tests, with various types of beacon lights placed on the roof of the laboratory of the Edison Lamp Works and observations made from Eagle Rock, at a distance of six miles, showed that the neon light was absorbed less in a fog than the white light of the mazda lamp of the same candlepower. However, the tests also indicated that in spite of the greater penetration of the neon lamp the mazda beacon is still best for the purpose because it is possible to use a more concentrated white light which used with a searchlight reflector produces much greater beam candlepower than any neon lamp. The neon lamp under the present development being without filament and merely an illumination of the gas within a bulb, does not produce the concentrated brilliance of the mazda lamp, which is necessary if the light is to be used in a searchlight reflector.

"The neon lamp is still in the experimental stage. Perhaps we may be able to find a means of producing neon light more concentrated and of greater brilliance. If we do it surely will have a great advantage over the white light for these tests have shown the pinkish glow can be seen further under all conditions. The new type bulb, or neon induction lamp, is a decided improvement over the neon tube light, with which the public is somewhat familiar because of its use in advertising signs. With an induction spherical bulb one and one-quarter inches in diameter we can secure the same candlepower that many hundred feet of neon tube light would be required to produce. Realizing that fog is one of the outstanding terrors of aviators, we have been busy for two or three years at the Cooper-Hewitt laboratory in Hoboken, as well as the Edison Lamp Works, trying out various kinds of light, hoping to find a light which will be able to guide aviators under the most adverse conditions. We have tried various types of mercury and caesium lamps as well as the neons, and have come to the conclusion that the pinkish neon light is best if we are able to find a way of producing this light of greater concentrated brilliance.

"At present the high brilliancy of the tungsten filament in the mazda lamp enables the production of a searchlight beam of many times greater candlepower than has been obtainable with neon and this more than offsets the greater fog penetrating ability of the neon lamps. Then too, at present there is greater simplicity in the operation of the mazda lamp as well as an appreciable difference in costs."

In the demonstrations, the mercury lamp was also shown as well as the neon and mazda, and observations from Eagle Rock were made with field glasses and various light-recording instruments. The possibility of using color screens on the mazda beacons, so that such guiding lights could be more readily picked out by aviators, especially when the beacon might be near a city with its thousands of other lights, was also demonstrated.

Aviation beacons are used to mark the various air routes, as well as the landing fields.



The Richmond Station—The Philadelphia Electric Co.

Underground Transmission At 66,000 Volts in Philadelphia

By **HOWARD S. PHELPS,**

Transmission and Distribution Department, Philadelphia Electric Company

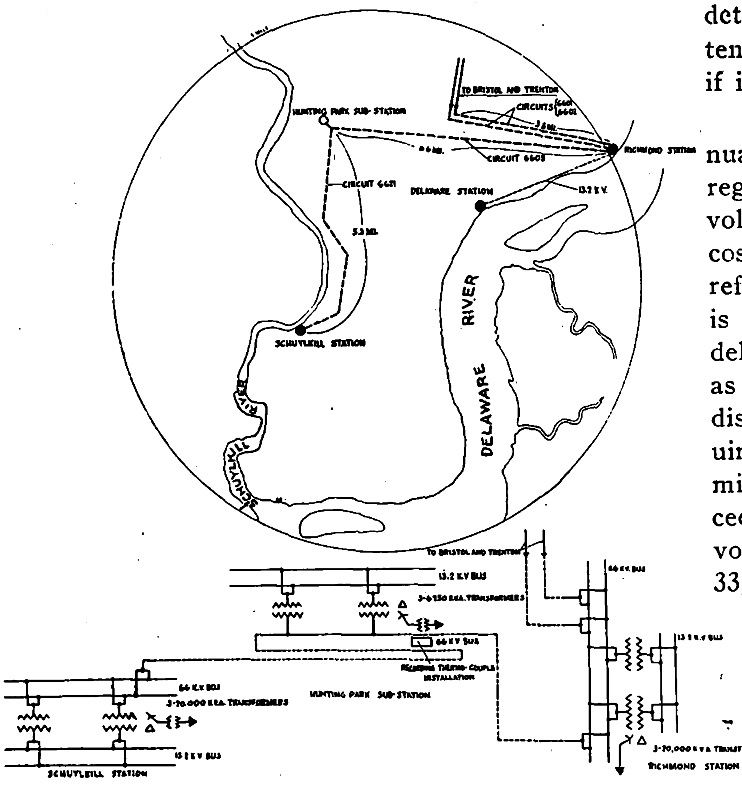
THE modern large capacity generating station has introduced a number of problems other than those pertaining to the economic combustion of fuel at high rates and the conversion of heat energy into electrical energy in extremely large generating units.

There is presented in the above illustration an aerial view of Richmond Generating Station of The Philadelphia Electric Company. This station is located on the Delaware River adjacent to the Pennsylvania Railroad Atlantic City Bridge in Tacony. Generating stations such as this must be located adjacent to a large supply of water. That is necessary in order to provide adequate boiler supply, for evaporation rates somewhat in excess of a ton of water per minute per boiler, and condenser cooling water, at a rate of between four and five tons for each ton of water evaporated.

Real estate prices are very important factors in selecting sites for these generating stations covering such large areas. In general, this factor alone will indicate the necessity for locating electrical stations at points quite remote from load centers.

Therefore, the requirements that the modern large generating station be located adjacent to a large body of water and at a point where land values are reasonable practically automatically restrict the routes of outgoing electrical circuits to a few streets leading toward the centers of consumption. With a limited number of streets available it is natural there may be much congestion of underground cable facilities in the vicinity of large generating stations. Under some circumstances this congestion may, of necessity, continue for a considerable distance from the station because of undeveloped streets in remote portions of a city or existing subsurface structure, for example, such as water and gas pipes and sewers. All of the foregoing factors, combined with increasing transmission distances and amounts of energy to be transmitted, indicate the necessity for ascertaining what advantages may be gained by utilizing underground transmission at voltages ranging from 44,000 volts to 66,000 volts and under some conditions even higher pressures.

Illustration No. 2 shows schematically the routes of underground cable rated at 75,000 volts which is in


HUNTING PARK SUB-STATION
TO BRISTOL AND TRENTON
CIRCUITS 6601 6602
3.8 MI.
6.6 MI.
CIRCUIT 6603
RICHMOND STATION
CIRCUIT 6631
DELAWARE STATION
13.2 K.V.
5.8 MI.
SCHUYLKILL STATION
RIVER
DELAWARE
SCHUYLKILL RIVER
TO BRISTOL AND TRENTON
13.2 K.V. BUS
3-6250 K.V.A. TRANSFORMERS
66 K.V. BUS
RECORDING THERMO-COUPLE INSTALLATION
HUNTING PARK SUB-STATION
66 K.V. BUS
3-20,000 K.V.A. TRANSFORMERS
13.2 K.V. BUS
SCHUYLKILL STATION
66 K.V. BUS
13.2 K.V. BUS
3-20,000 K.V.A. TRANSFORMERS
RICHMOND STATION

MAP OF 66 K. V. UNDERGROUND TRANSMISSION FACILITIES AND SCHEMATIC DIAGRAM OF CONNECTION

operation at 66,000 volts in The Philadelphia Electric Company System. Two circuits, each 3.8 miles in length, have been installed from Richmond Station to "G" and Luzerne Streets. At that location they connect to aerial lines supplying energy to Bristol, Pa., and Trenton, N. J. Two circuits, each 6.6 miles in length, have been installed between Richmond Station and Hunting Park Substation. These circuits are continued a distance of 5.8 miles from Hunting Park Substation to Schuylkill Station. There is then a total of 32.4 circuit miles or 97.2 conductor miles of 750,000 circular mil single-conductor paper-insulated lead-covered underground cable rated at 75,000 volts between conductors.

Data with respect to the operation of underground cable of the character under discussion are very limited. Therefore, temperature recording equipment has been installed in conjunction with thermocouples attached to the cable sheaths and in spare ducts in the duct structure. The location of these facilities on Westmoreland Street will be observed by reference to illustration No. 2.

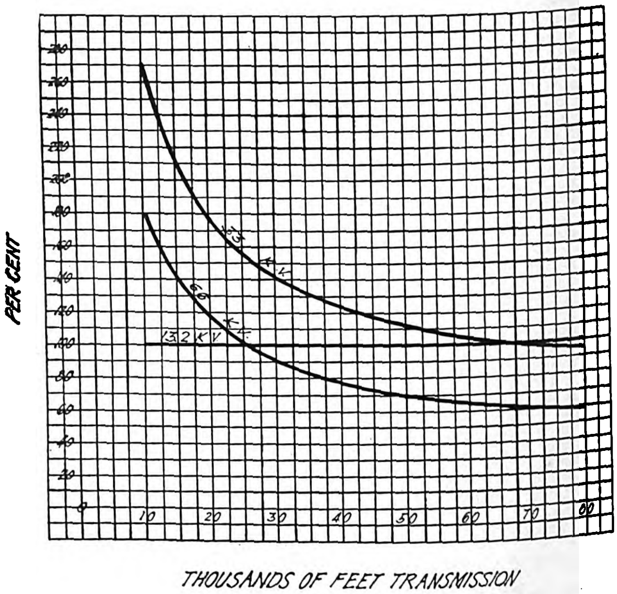
The problem of getting energy away from such stations as Richmond is obviously influenced by the operating voltage selected for transmission. In The Philadelphia Electric Company system there already was the 66,000 volt aerial tie-line between Chester and Schuylkill Stations. It was, therefore, necessary to determine if operation at that voltage could be extended to underground transmission economically or if it would be better to adopt a lower voltage.

Comparative studies were made of the Total Annual Costs to transmit to different distances an unregulated load of 100,000 K.V.A. at voltages of 13,200-volts, 33,000-volts and 66,000-volts respectively. The costs for transmission at 13,200-volts were taken as a reference for comparison since it is that voltage which is used almost exclusively for transmission in Philadelphia. The results of this study are quite striking as observed from illustration No. 3. For transmission distances up to 27,500 feet it was found that continuing the present practice of 13,200-volts for transmission was the most economical. For distances exceeding the limit indicated, transmission at 66,000-volts is more economical than either 13,200-volts or 33,000-volts. Transmission at 33,000-volts is less economical than that at 13,200-volts at all distances less than 67,500 feet and at no distance is 33,000-volt transmission as economical as at 66,000-volts. While the unit price of equipment for transmission at either 13,200-volts or 33,000-volts is materially less than the unit price for 66,000-volt equipment, the latter gains an early advantage through the use of a less number of units. These facts are illustrated below.

Following the decision to undertake underground transmission at 66,000-volts, the leading cable manufacturers were asked to submit their recommendations

APPROXIMATELY RELATIVE OVERALL ANNUAL COSTS PER KVA OF UNDERGROUND TRANSMISSION AT

13200 - VOLTS
33000 - VOLTS } FOR 100,000 KVA DELIVERED UNREGULATED
66000 - VOLTS



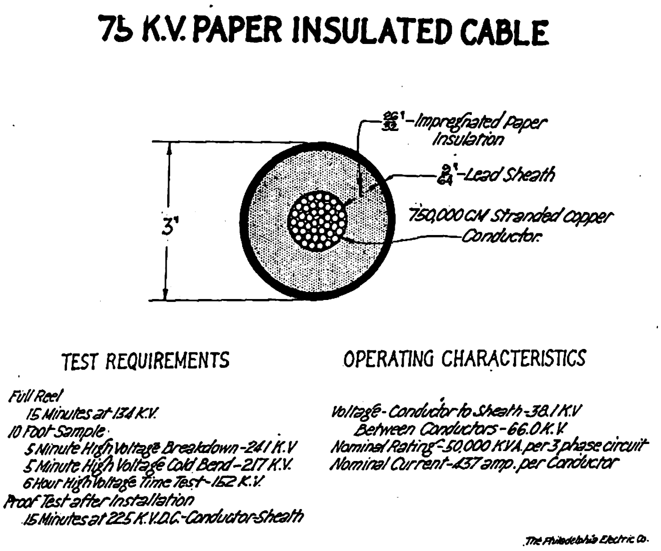

75 K.V. PAPER INSULATED CABLE
26/32"-Impregnated Paper Insulation
9/64"-Lead Sheath
750,000 CM Stranded Copper Conductor.
3"
TEST REQUIREMENTS
Full Reel
15 Minutes at 134 K.V.
10 Foot Sample
5 Minute High Voltage Breakdown-241 K.V
5 Minute High Voltage Cold Bend-217 K.V.
6 Hour High Voltage Time Test-152 K.V.
Proof Test after Installation
15 Minutes at 225 K.V.D.C.-Conductor-Sheath
OPERATING CHARACTERISTICS
Voltage-Conductor to Sheath-38.1 K.V
Between Conductors-66.0 K.V
Nominal Rating-50,000 KVA. per 3 phase circuit
Nominal Current-437 amp. per Conductor
The Philadelphia Electric Co.

Illustration No. 4

for cable satisfactory for operation under the following conditions:

(1) 50,000 K.V.A. Continuous load.
(437 amperes per phase at 66 K.V.)
(2) 75,000-volts.
(3) 25° C. Maximum temperature of soil surrounding ducts.
(4) Not more than two circuits of these characteristics in the same duct structure.

Illustration No. 4 shows the principal dimensions of the cable it was eventually decided to buy. The recommendations of each of the manufacturers were substantially the same as those set forth in the illustration. While the cable purchased in 1925 for the initial installation had 30/32" of oil impregnated paper insulation, that purchased subsequently has had 26/32" of oil impregnated paper insulation. Approximately 80% of this class of cable installed in Philadelphia has the lighter thickness of insulation.

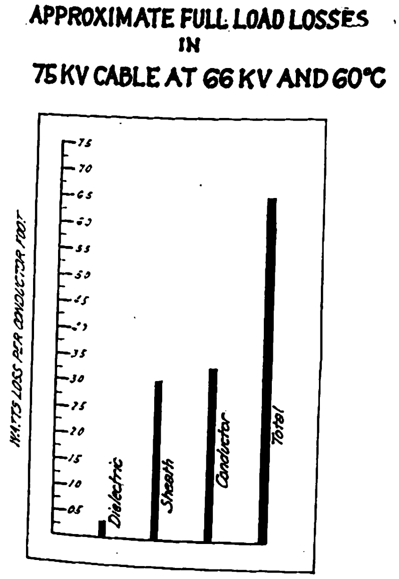


Illustration No. 5

This cable has been manufactured and tested in conformity with "Specifications for Impregnated Paper Insulated Lead Covered Cable, Association of Edison Illuminating Companies." For this particular cable there was a factory test at 134,000-volts 60 cycles, A.C. for fifteen minutes on each reel. It was also a requirement that 10-foot samples, designated by the purchaser, should successfully withstand 241,000-volts 60 cycles A.C. for five minutes. To successfully withstand an accelerated life test at 152,000-volts 60 cycles A.C. for a period of not less than six hours was another requirement imposed upon selected 10-foot samples. Immediately following the accelerated life test a high voltage breakdown determination was made upon the same sample. In all cases the high voltage breakdown was found to be well in excess of 300,000-volts. All factory inspection and tests were made by The Electrical Testing Laboratories, Inc., of New York City.

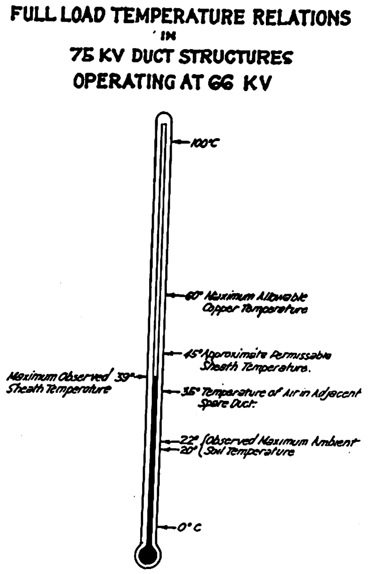

FULL LOAD TEMPERATURE RELATIONS
IN
75 KV DUCT STRUCTURES
OPERATING AT 66 KV
100°C
60° Maximum Allowable Copper Temperature
45° Approximate Permissable Sheath Temperature.
Maximum Observed Sheath Temperature 39°
35° Temperature of Air in Adjacent Spare Duct.
22° 20° Observed Maximum Ambient Soil Temperature
0°C

Illustration No. 6

Following the installation of these circuits they were subjected to a Kenotron voltage test of 225,000-volts D.C. to ground for a period of fifteen minutes with the three conductors tied together and the same voltage for the same time interval for each conductor against the two remaining conductors tied together and connected to ground.

Illustration No. 5 presents graphically some interesting full load data pertaining to this cable. These data relate to the losses per foot of cable and therefore should be multiplied by the factor three to express the relations per circuit foot. Expressed in a

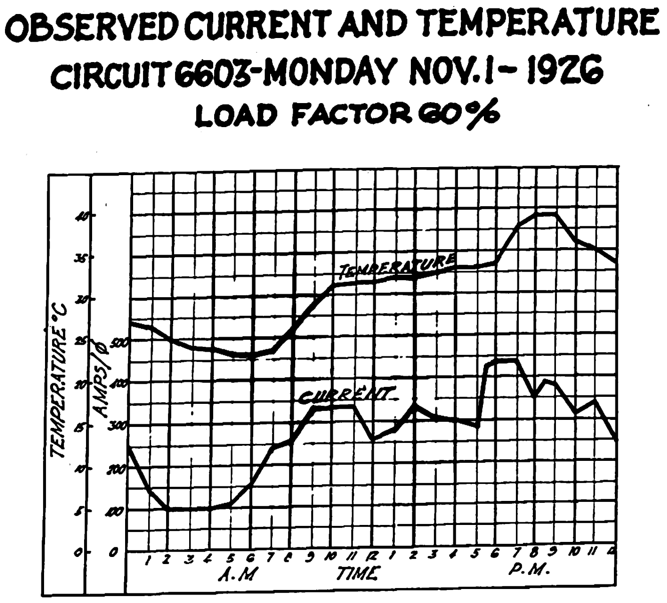


Illustration No. 7

manner a bit more readily visualized, the losses per circuit foot are equivalent to 20 watt lamps spaced 12″ on centers throughout the length of the run for each of the two circuits. However, when considering the transmission capacity of these circuits this apparently very high loss is quite nominal and the overall transmission efficiency is somewhat greater than 97%.

"Full Load Temperature Relations" are set forth in illustration No. 6. A temperature of 60° C. has been established as the maximum permissible for the copper. The corresponding maximum sheath temperature is then 45° C. as determined by a temperature gradient of 15° C. between copper and sheath. Actual determinations of sheath temperatures by means of thermocouples, referred to earlier, discloses that the maximum which has been attained in operation is 39° C. This difference of 6° C. between the calculated permissible and the observed actual shows quite conclusively that the rating of 50,000 K.V.A. continuous load is conservative.

Illustration No. 7 shows a typical load cycle of a 66,000-volt cable circuit together with the corresponding temperature cycle for conditions existing during the early part of 1927. It is interesting to note that temperature changes lag the corresponding current loading by about one hour.

In conclusion it is quite obvious that electrical energy can be and is successfully transmitted over underground cables at 66,000-volts. The problem which it was initially felt might be very serious, namely, the satisfactory splicing of this class of cable, has been easily overcome. The Central Station Industry is pushing forward still further in its investigation of the possibilities of underground transmission at high voltages and before the close of 1927 there will be at least two systems in this country operating long transmission circuits at 132,000-volts.

Warm Air Heating for Residences

The co-operative agreement between the National Warm-Air Heating and Ventilating Association and the University of Illinois, which has been in effect since October, 1918, provides for the investigation of warm-air furnaces and furnace heating systems. Under the terms of this agreement a very extensive study of furnace heating problems has been made, using first an experimental plant with auxiliary equipment in the laboratory, and later a typical modern residence erected by the Association for the express purpose of correlating and extending the work in the laboratory to the conditions of actual installation.

The work in the research residence has been in progress for the past three heating seasons and a great quantity of valuable data relating to the performance of a warm-air furnace heating system has been obtained. These data are of first importance to the designers, installers, and owners of such heating systems, covering as they do all the weather conditions encountered during the heating season. Naturally, the greatest interest in the performance of any heating plant attaches to the records secured under the worst weather or load conditions. The blizzard and cold wave of January 13, 14, and 15, 1927, provided an exceptionally good opportunity of studying typical warm-air heating plant performance under maximum load conditions, and this circular summarizes the more important results obtained over a 48-hour period during which the outside temperature averaged 3.1° F.

Circular No. 15, Engineering Experiment Station, University of Illinois, Urbana, Illinois, price 15c, gives results of experiments during the past winter.

A future Bulletin of the Engineering Experiment Station will present complete results and comparisons of different systems for a period of several heating seasons.

Defects in Timber Caused by Insects May Be Largely Prevented

Bulletin 1490-D, "Defects in Timber Caused by Insects," just issued by the Department of Agriculture, presents facts which will aid in determining the nature and cause of these defects, gives recommendations for avoiding preventable injury, and discusses the types of defects which are not preventable. The principal damage comes under two types of defects, designated as wormholes, with no living worms or decay, and powder post. Powder post occurs only in the seasoned or partially seasoned sapwood or heartwood. This type of injury is dangerous, since the grubs continue their destructive work in the wood and also infest other timber near by.

Methods to adopt in reducing the losses from powder post depend on which species of insect does the damage. Four or five different ones are listed in the bulletin as causing this type of defect. In some cases the practice recommended is to treat finished wood products with substances such as paraffin wax, varnish, or other fillers which will close the pores and prevent egg laying. Effective remedies include kiln-drying at high temperatures; steaming at 130 degrees F.; and treatment with a mixture of kerosene and coal-tar creosote, after which the material should be kept in quarantine. Submerging the logs in the mill pond and prompt utilization will prevent much loss from attack by some insects.

Special reference is made in this bulletin to the protection and conservation of both crude and finished wood products, such as lumber, belts, cooperage stock, agricultural implement handles, tent poles, vehicle parts, timber for ship building, oars, airplane stock, and other high-grade products.

A copy of the bulletin may be obtained by writing to the United States Department of Agriculture, Washington, D. C.

Safety and Production*

By L. W. WALLACE,
Executive Secretary, American Engineering Council

EARLY in 1926 American Engineering Council appointed a special committee to make an engineering and statistical assay of the comparative relationship between industrial accidents and production. Council undertook the study upon the request of the National Bureau of Casualty and Surety Underwriters which provided the necessary funds for its execution. A satisfactory program was soon developed and a working organization set up at Council headquarters in Washington. During 1926, information nationwide in scope and broadly representative of existing conditions was secured, from which a forcible report has been prepared. This is now being published in book form and will be ready for distribution about October 1st.

Information was secured from about 14,000 companies, with an aggregate experience of 122,000 company years. These companies had in 1925 approximately two and one-half million employees, or one-fourth of the industrial workers of the country. This is equivalent to over eighteen million man-years, or over fifty billion man-hours.

No effort was made to determine the direct casual relationship between the factors which influence accident and production rates. It would be practically impossible to do so because an improvement in productivity is due to a multiplicity of factors many of which also affect the accident rates. Likewise it will be readily conceded that the converse is true.

The primary objective of the study was to prove or disprove the common belief that a safe factory is an efficient factory and that an efficient factory is a safe factory. The Committee has accumulated sufficient evidence to indicate beyond the possibility of doubt that this premise is correct.

The accident and production performance of twenty major industries and over 120 major product groups will be presented in the published report. The experience of some of the groups will be given in the following paragraphs:

Automobile

The combined experience of four large automobile companies with 14,427 employees shows an increase of 20 per cent in the rate of production over the four-year period, from 1922 to 1925. This was accompanied by an increase of 4.0 per cent in the accident frequency rate, and an increase of 22 per cent in the severity rate. There was a wide difference in the accident rates of the individual companies.

Building

The building industry was originally among those to be studied. From the outset, it was realized that it would be difficult to secure appropriate information because of the possible lack of accident data and unavailability of a suitable unit of production. However, an earnest effort was made to obtain data of the character desired. Almost invariably, it was found that contractors and builders did not keep accident statistics. Those that did could not supply production data in any usable form. For these reasons a treatment of the building industry could not be developed for the report. However, it was determined that a great many accidents are occurring in the industry and far less attention has been given the matter than its importance warrants.

Cement

One hundred and twenty cement companies with approximately 35,000 employees and manufacturing 90 per cent of the output of the United States experienced and increase of 32 per cent in the rate of production from 1922 to 1925, a simultaneous decrease of 29 per cent in the accident frequency rate, and a 30 per cent decrease in the severity rate.

Chemical

The chemical industry from 1921 to 1925 had a marked increase in the rate of production. This accomplishment was attended with a reduction in the accident frequency rate, which declined faster than the production rate increased. A large reduction occurred in the severity rate in some of the product groups of the industry.

Electric Light and Power

The electric light and power industry in general is making but a slight increase in the rate of production expressed in kilowatt hours generated per man-hour. The combined production rate of 25 companies with 24,092 employees, increased only 2 per cent from 1921 to 1925; the accident frequency rate decreased 3 per cent; and the severity rate decreased 22 per cent.

Electric Railways

Apparently little change is taking place in the production rate of the electric railway industry. However, from 1920 to 1925 the accident frequency rate decreased 39 per cent.

Gas

The combined experience of seven gas companies with 2,278 employees, shows a decrease of 8 per cent in the production rate from 1921 to 1925, a decrease of 24 per cent in the accident frequency rate, and a decrease of 61 per cent in the severity rate.

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*Reprinted from The Bulletin of the Minnesota Federation of Architectural and Engineering Societies, for August, 1927.

Iron and Steel

It is evident that in general an increase in the rate of production for the iron and steel industry has been accompanied by a remarkable reduction in the accident frequency and severity rates.

Machine Building and Metal Working

The accident and production performance of the plants studied in the machine building and metal working industry was not uniform. In most divisions there occurred a considerable improvement in productivity. In some divisions this was accompanied by decreases in the frequency and severity of accidents while in other cases increases took place. The non-ferrous plants in the industry experience a consistent and substantial improvement in productivity, and a marked unfavorable accident performance.

Mineral Mining

The mineral mining industry represented by 2,783 companies with 123,128 employees, experienced an increase of 50 per cent in the rate of production from 1916 to 1924. This was accompanied by an increase of 14 per cent in the accident frequency rate, and a decrease of 17 per cent in the severity rate.

Paper and Pulp

The analysis of the data received from fifteen plants in the paper and pulp industry shows as favorable and as uniform a performance in accidents and production as that of any industry studied. The rate of production increased 19 per cent during the five-year period from 1921 to 1925 while simultaneously the accident frequency rate decreased 18 per cent, and the severity rate decreased 31 per cent.

Quarry

The quarry industry from 1916 to 1924 made but slight improvement in its accident and production performance. There was an overall increase of 12 per cent in the rate of production for 1,660 quarries, accompanied by an increase of 3 per cent in the accident frequency rate, and a decrease of 13 per cent in the severity rate.

Steam Railways

Upward trends in the rate of production and downward trends in both accident frequency and fatality rates have been the experience of steam railroads during the past ten years. The analysis covered the experience of 176 companies operating 90 per cent of the total mileage of the United States. The trend curves for both the freight and passenger service of the industry show that the general upward trend for production and downward trend for accident rates has been the situation not only for the longer ten-year period but also for each year. The comparison of the accident rates by crew groups gives positive evidence that the accident prevention measures applied by the roads have not been confined to any one group, but that all employees are encompassed in programs of safety.

Telephone and Telegraph

From 1922 to 1925 a reduction of 62 per cent in the accident frequency rate occurred among 82,000 male plant forces of the telephone and telegraph industry. This was accompanied by an increase of 26 per cent in the rate of production.

Woodworking

The experience of plants in the woodworking industry is generally favorable in productivity but unfavorable in accidents. During the past few years substantial increases have been made in the rate of production by most groups and individual companies. This performance has been accompanied by marked increases in either the accident frequency or severity rate.

The experience of five companies manufacturing woodworking products, with 1,440 employees, from 1922 to 1925, shows an increase of 37 per cent in the production rate, accompanied by an increase of 1 per cent in the accident frequency rate, and an increase of 123 per cent in the severity rate.

The combined experience of twelve furniture plants, with 3,852 employees, for ten years from 1916 to 1925, shows an increase of 141 per cent in the rate of production accompanied by an increase of 35 per cent in the accident frequency rate, and a decrease of 56 per cent in the severity rate.

Findings

The Committee, after a very painstaking and exhaustive analysis of the data, has drafted a number of most significant findings. Among them are the following:

Maximum productivity is dependent upon the reduction of accidents to an irreducible minimum.

In recent years in well managed plants, marked increases in productivity have occurred simultaneously with equally marked reductions in the frequency and severity of accidents.

The rate of production per man-hour for the industries studied was 14 per cent higher in 1925 than in 1922.

The rate of accident frequency per man-hour for the industries studied was 10 per cent lower in 1925 than in 1922.

The rate of accident severity per man-hour for the industries studied was 3 per cent higher in 1925 than in 1922.

Eighty per cent of the individual groups studied experienced increases in the rate of production; 52 per cent decreases in the accident frequency rate; and 68 per cent decreases in the accident severity rate over the period covered.

The initial or accompanying cost of industrial accidents is much greater than is commonly believed.

Minor accidents are accountable for a much larger amount of productive time and value lost than is generally recognized.

Effective organized safety work is being carried out in a relatively small percentage of industrial plants.

Many industrial executives have not given to accident prevention that degree of executive attention and direction that its economic and humanitarian significance warrants.

The accident and production performance of the best plants in each industry clearly shows that tremendous improvements can be achieved by the remaining plants in each industry.

The report will contain the following recommendations prepared by the Committee:

That the same executive direction and control be given to decreasing industrial accidents as is given to increasing productivity.

That those agencies which collect and disseminate accident statistics adopt uniform terminology and standardize records so that they may be compiled on a comparable national basis.

That the executives of those plants having high accident frequency and severity rates initiate, direct, and control ways and means of decreasing their accident rates to at least the low rates obtained by other plants in their industry.

That industrial trade associations, engineering societies, and other agencies, concerned with the improvement of industrial operation, bring to the attention of their members the necessity of improvement in a safety performance as a vital step in the strengthening of their industrial position.

That industrial trade associations secure, compile, and analyze accident statistics for the purpose of determining the lowest accident rates possible of attainment for their respective industries.

That industrial trade associations endeavor to secure such action on the part of executives of their industries as will result in each plant having the lowest accident rates obtainable.

Riveted Steel

By A. F. JENSEN

President, Hanna Engineering Works, Chicago, Ill.

THE word which I enjoyed hearing was "moderation" as conveyed by President Farmer, of The American Welding Society. We hope these get-togethers will develop that moderation for we are anxious to have it. Individually, we are not in position to meet the publicity program of the American Welding Society, but I dare say the manufacturers of rivets, pneumatic tools and fabricating machinery are, and if that is necessary to develop a riveting consciousness we will simply have to do it. We would much rather, and we are ready to co-operate with any engineering body which has for its object the consideration of methods of joining metals be it by welding or riveting.

We come to you not with our personal opinions, but quote individuals who are in position to give an unbiased opinion on the relative merit of these two processes.

Riveting is one of the oldest arts and there are no intangibles when considering its application. Accurate data are available regarding every phase and type of riveting; inaccurate assumptions on the riveting side of the comparison are inexcusable.

There was a reference earlier in the evening to corrosion. We have condensed the results of a questionnaire reported in the paper "Corrosion in Structural Steel" read by Mr. Frank W. Skinner at the annual convention of the American Institute of Steel Construction.

Probably one million tons of steel bridges were erected in this country between 1890 and 1900, nearly all of which are still in service, except when too light for increased traffic. On the Pennsylvania east of Pittsburgh, some 500 bridges built previous to 1897 are now in excellent condition, notwithstanding the large increase in loads to which they have been subjected. There are seventy thousand linear feet of bridge structures on the Lehigh Valley. The oldest structure is about sixty years old, and none has been replaced except on account of accident or unduly increased loads. Some of the New York Central and Hudson River bridges have been in service forty years. Other notable examples are the steel arch ribs of the famous Eads Bridge over the Mississippi River at St. Louis, which have seen fifty-two years of service, and the trusses of the Brooklyn Bridge in service forty years. When the Blair Railroad Bridge over the Mississippi was removed after forty years' service, the structure showed no signs whatever of deterioration. Is there a better monument to the dependability of the riveted joint?

In all data on structural welding which I have read it is obvious that the welder knew the weld was for test purposes. The most skilled and conscientious welders have been employed; supervision has been close and comprehensive and the conditions have been test conditions, all of which will not prevail on mass production.

We quote from an article "Structural-Steel Welding" on page 974, Volume 48 of Mechanical Engineering:

"Essentially, the main objection is the fact that not only does the personal equation enter with particular importance into all welded work, but thus far no way has been discovered to determine the degree of excellence of a welded joint after it has been made. Because of this there may be quite a margin between what can be done by welding and what actually will be done under commercial conditions, with such labor as may be obtainable if welding be applied on that vast scale which would be required in actual building procedure."

In a paper, "Testing Gas Welds," presented at the International Acetylene Association Meeting in Chicago, November 11, 1926, Professor H. L. Whittemore of the Bureau of Standards said:

"One of the important problems in commercial welding is to obtain good welds with certainty. This involves not only good workmanship but good judgment. Most of us can point to welds which should never have been made. Any failure of welded structures leads to an undue restriction of all welding, both good and bad. The apparent ease with which the technique of welding can be learned and the paying of welders on a piecework basis have not always resulted in workmanship which is a credit to the industry. Undoubtedly the quality of work would be greatly improved if conscientious and competent inspectors were in charge of the fabrication. . . .

"The great disadvantage of specimens made expressly for test is that they do not necessarily represent the regular output of the welder. Although impact specimens can be cut from a structure such as a tank and the structure repaired for service this is not practical in most cases. Whether or not specimens for test truly represent the work the welder is doing depends largely upon the moral qualities of the welder. Welding for the best results requires workmen who realize the responsibilities placed upon them and who consistently refuse to do work which they know is unsatisfactory. We should do all we can to create this spirit of craftsmanship and take off our hats to welders who have it."

Methods and machinery used in riveting have practically eliminated the necessity for skilled workmen. Industry's greatest problem today is that of man-power and it is, therefore, but a logical conclusion that those qualified by experience in the problem of the fabricating shop should consider the importance of the human element in welding as paramount.

The following from the catalogue of a manufacturer of welding wire is interesting:

"No one who has watched an electric welder in operation needs to be told that the process imposes a severe nervous strain on the man who is doing the welding. He must work behind a cumbersome mask, frequently in an awkward position, and he must hold his hand steady to a hair's breadth all the time he is depositing metal. His skill at manipulation must compensate for the differences in arc length as the drops of molten steel come off the end of his rod. If he draws his arm back a fraction of an inch too far his arc goes out, and if he touches the work with the rod it freezes. Under these circumstances it is not surprising that the average welder is only depositing metal during forty to sixty per cent of the time he is paid for. The rest of the time he is coaxing his electrode along or is resting. This does not mean that he leaves his work; but he takes a little longer than is necessary to change his electrode, he shifts his position frequently and in numberless ways he seeks relief from the nervous fatigue of his work."

One of the great advantages of riveting is in the aligning and locating value of the matched rivet holes. They predetermine the squareness of the structure irrespective of the erectors. Rivet holes are located in the shop where their accuracy may be established with certainty and economy and with the assurance that the discriminating plans of the designing engineer are conformed to in the field. They establish location, level and squareness surely and quickly.

In the December, 1926, issue of the Journal of the American Welding Society, reporting the discussion of papers read at the fall meeting a member asked, "I wonder whether the question of tack welding on each end as material is erected has been looked into, thereby saving all punching and handling in the shop for these bolted connections for field erection." Mr. J. R. Edwards, American Bridge Company, Chairman Structural Steel Welding Committee, answered, "I think if the man that asked that question would have seen the speed at which the building was going up he would have found out very quickly that that would be impossible. They made those connections so quickly that you could not have a man around there to tack it."

A considerable item of cost not incurred in riveting but necessary when welding is that beams must be machined to length and ends squared. We quote from a paper, "Welding of Iron and Steel," by Mr. Comfort A. Adams, Director, American Bureau of Welding:

"One of these difficulties relates to the tolerances as to length, camber, etc. For example, beams are now ordered one-half inch 'short' with a plus or minus tolerance of ⅜". In a welded structure, these large tolerances would be very objectionable, as they would require either an excessive amount of weld metal to fill up the joints, or the use of brackets and angle connecting pieces, the elimination of which constitutes one of the savings of the welding process. The exact widths of web plates and the absence of considerable camber are not always of importance in riveted girders, but are of considerable importance in the case of welding."

Resuming our quotations from the paper, "Testing of Gas Welds":

"One objection to welding which does not apply to other methods of fabrication is that the process causes initial stresses in the structure, the magnitude of which is unknown."

On the subject of internal stresses, welding of field joints has given way to riveting on the Mokelumne project which is to bring a new water supply to Oakland, California, and other municipalities in the East Bay Municipal Utiltiy District. In laying the 65" steel pipe line about twenty-six thousand feet of the line, at the outset of the work, was connected by butt-welded circumferential joints made in the trench.

We quote from an article by Arthur P. Davis, Chief Engineer, in the December 2, 1926, issue of the Engineering News-Record:

"Before this length of the line had been completed, it was evident that satisfactory field welds could be made only with great difficulty and even after ample time for organization and a considerable amount of experience with all field conditions a considerable percentage of the field joints had to be done over. It was then decided that a change to riveted butt-strap joints was justified and this was accordingly ordered.

"Fundamentally, the reason for the change was that with the methods used on this job the large diameter of the pipe seemed to make it very difficult to equalize temperatures so as to avoid internal stresses in the metal plates. The longitudinal electric welds, made under shop conditions with equipment and methods quite different from those applied in the field, have been able to pass severe pressure and hammer tests and to date have been satisfactory to the district both in quality and speed of production. . . .

"On the outside of the pipe the oxyacetylene process was used, two welders usually working simultaneously on a joint. . . .

"After completing the external weld an electric arc was used on the inside to supplement or 'back up' the external weld and to insure proper fusion of the external edges of the adjoining plates. . . .

"The oxyacetylene welding being a rather slow process caused much expansion of the pipe metal and introduced unequal internal stresses in different parts of the circumference. These stresses were sufficient in numerous cases to cause the joints to crack open as the completed weld cooled. For example, with adjacent edges to be welded spaced about ¼", welding could proceed only a short distance before expansion due to the heat of the welding had closed this space ahead of the weld and caused a compressive stress between the abutting plates sufficient in many cases to cause overlapping. This condition resulted in the almost continual necessity for cutting out pieces of the plate ahead of the weld in order to make progress possible. . . .

"Another difficulty was due to the temperature differences caused by the necessity of laying the pipe in the summer time with the heat of the sun warming its upper surface. Differences of 80° F. between the temperature of the top of the pipe and the temperature of the metal in contact with the bottom of the trench were observed. That is, when the bottom of the pipe had a temperature of about 60° F. the top of the pipe exposed to the sun would have a temperature of about 140° F. The conditions at night were reversed, that is, the top of the pipe exposed to the cool night air was cooler than the metal in the bottom in contact with the ground.

"To compensate for this temperature difference as the welding progressed portions of the plate at the top of joints had to be cut out. This had its bad effect, however, in that when the pipe cooled there was tension along its top greater than elsewhere on the circumference. In one instance where a circumferential weld broke from shrinkage this greater internal stress in the top of the line was sufficient to raise the released ends of the pipe 3 or 4 inches off the bottom of the trench. . . .

"Various schemes were tried to take care of the expansion and contraction in the trench due to atmospheric temperature changes. At first every tenth joint was left open. When it was found that a considerable number of the joints still pulled apart the plan was changed to leave every third joint open. This did not seem to materially affect results; joints would break only one length (30 ft) from an open end that was free to move. The plan of laying up the joints continuously without any openings was then tried, depending on the strength of the welds to prevent rupture of the line. When these expedients all failed to meet the requirements of a fully satisfactory job the change to riveting was ordered."

The opinions presented are those of authorities qualified by experience to give an unbiased opinion upon the relative merit of the welding and riveting processes. Knowing your vital interest in the subject, we are pleased to give the following additional data:

Examination of a wrecked brine cooling tank, the failure of which resulted in the death of one man and the serious injury of six others, disclosed that the weld extended in some places to a depth of but 1/16", or but one-sixth of the thickness of the plate.

Another disastrous explosion was that of a sulphate digester killing three, injuring four, and causing property loss of $150,000. It was 72 inches in diameter, 25 feet high, of ½-inch steel plate, and welded construction throughout. For about one-third of the distance around the lower seam there appeared to have been very little of the metal actually joined in the weld. The only portions of the defective part of this joint that appeared to have been properly welded were at the edges of the scarf.

Such failures have not been confined to working installations alone. An electric arc welded tank, 60 inches in diameter by 7 feet long with 3/16-inch shell and ¼-inch heads, and intended for oil storage, was being tested by the builder at 15 pounds air pressure, a regular practice in many boiler shops. Its failure resulted in the death of two men. Tests of the safety valve immediately after the explosion showed that it released at 15 pounds pressure. Subsequent examination of the longitudinal weld revealed a portion that was poorly welded, representing more than one-third of the total length.

The foregoing failures are quoted from The Locomotive, inssued quarterly by the Hartford Steam Boiler Inspection and Insurance Company.

Mr. Wm. H. Boehm, Vice-President of the Fidelity and Casualty Company in an article "Disastrous Accidents" in the August 31, 1926 issue of Power says:

"A crack was discovered in the turn of the flange of the lower head in a large vertical boiler. An employee prided himself on his skill in autogenous welding and did what he considered to be a fine job in the welding of this crack. He was so well satisfied with it that, after discovering that similar cracks were beginning to form in the heads of the three other boilers alongside of the first one, he welded them also. Two weeks later one of the boilers violently exploded, knocked down the other three and completely wrecked the building. One man was killed."

The fifteenth annual report of the Bureau of Locomotive Inspection, Interstate Commerce Commission, describes the failure of a main air reservoir which ruptured along the line of a fusion weld as follows:

"This reservoir had wasted away from an original thickness of ¼" to about 1/32" and had been repaired by welding because of a leak where it had corroded through. This locomotive had been used only two days after the reservoir was welded. Had any reasonable inspection of this reservoir been made as required by the law, its defective condition would have been found and the folly of attempting to make repairs by welding would have been apparent."

In addressing the San Francisco Fabricators, Mr. Lee H. Miller, Chief Engineer of the American Institute of Steel Construction, had this to say,—quoting from the February 3, 1927 issue of The Iron Age: "Mr. Miller advised caution in the use of welding in the fabrication and erection of structural steel. He said that a number of tests are being made by engineers independently and in co-operation with the American Institute of Steel Construction. A Committee of the American Society of Civil Engineers, he said, 'is also conducting experiments.' He stated that the welding of structural steel is still in early stages of development, that there exist a number ot conflicting theories about it which will have to be clarified, and that if welding is used indiscriminately by the fabricating industry, without a thorough study of its possibilities and limitations as a method, there may be serious consequences. Mr. Miller stated that he did not wish to be understood as condemning welding. 'It can be done,' he said, 'but there are not as yet enough positive facts about it in connection with structural steel to enable anyone to speak authoritatively.' "

To compare the possible future development of welding with riveting practice as it now exists is to assume that the riveting art is at a standstill, an assumption not justified. There is a field of usefulness for both riveting and welding. The dependability of riveting and its contribution to engineering progress are reflected in every direction and mere claims and propaganda for a radically different new method will not supplant it. Riveting is fundamentally sound, has played a very important part in the development of our most important industries and will only be supplanted by methods more economical, less dependent on skilled labor and assuring equal safety. Riveting stands firmly on its record, an accredited success as a fabricating process.

Illumination of Flying Fields*

By CAPT. J. E. WHITBECK

Captain J. E. Whitbeck was, for the past six years, Superintendent of the Air Mail, Eastern Division, Chicago to New York, now has undertaken the operation of Hadley Field, New Jersey. This field is the main airport for the mail planes at New York.

IN presenting this paper on the subject, "Illumination of Flying Fields," do not let me infer that I am an authority on this subject because it is such a new one that no one has had sufficient opportunity or experience to know very much about lighting for night flying, I shall not attempt to go into the technicalities of illuminating engineering, but will endeavor to review briefly what has been done to date and give you the concensus of opinions with reference to the results that have been obtained.

Perhaps we should make it clear that this paper is based on lighting for commercial flying rather than military flying as there is good and sufficient reason to draw a very definite line between the two, for wartime military flying it is impractical to use any extensive lighting on the actual fighting front as it would necessarily attract and disclose too much to the enemy. The peace-time military flying is generally done when weather conditions are average or better and it is not necessary to have high intensity illumination for such weather conditions. I do not mean this as any criticism of the lighting that is being done on military fields; in fact, I think they are doing quite the right thing to meet the needs of their services. It should also be considered that a military plane does not usually fly over the same course. In fact, their duties and training may take them almost anywhere in the country or even to foreign countries which is a very good reason for their carrying quite extensive lighting equipments on the planes themselves and in most types of military planes they can afford to carry both large generators and batteries whereas with the commercial plane every possible pound must be saved for pay load and as the commercial plane usually flies over a certain definite route on a regular schedule it is quite reasonable to provide a large portion of the lighting equipment on the ground. A few years' study of the conditions that must be met in lighting for commercial night flying impresses me that it is a really comprehensive problem and that the details and local conditions concerning each field, should be very carefully analyzed before selecting lighting equipment.

The Air Mail Service started its first regularly scheduled night flying about three years ago and when the engineers of the Post Office Department attempted to write specifications for the lighting equipment they were confronted with the fact that there was no precedent to be guided by and that there was practically no standardized lighting equipment for commercial work, particularly field flood lighting. Suitable field lighting equipment was very difficult to secure, in fact the Post Office Department Engineers went to the manufacturers of lighting equipment and asked them, "What have you that can be used for this purpose?" Several of the manufacturers responded nobly and supplied flood lights of the projector type with which the first commercial night flying experiments were made. These lights answered the purpose fairly well and, no doubt, were the best thing available at that time. However, the search for better equipment was continued and arrangements were made to import a number of the large 180 degree flood lights using Fresnel lenses and equipped with 150 ampere arc. These lights were developed originally by the French Government; several millions were expended on this work. These lights are the standard equipment for field flood lighting in the Air Mail Service. They are expensive, and perhaps they give more light than is necessary a large percentage of time. However, when bad haze or fog conditions exist at night the high intensity lighting has helped to maintain the high percentage of performance that the Air Mail Service has shown (approximately 95 per cent for both day and night flying). Of course flood lighting, while the most important, is only one phase of the lighting that is required on the terminal field.

In addition boundary lights are quite essential to outline the field to the pilot very much the same way that a fence around a field would outline it to him in the day time. Boundary lights are usually placed at about 200 feet intervals and the equipments used is quite similar to street lighting practice. Six and six-tenths ampere, 600 lumen, lamps are used on series circuit, vapor proof condulets with marine type globes supported on a pipe standard about 3 feet high are the common practice. Current is supplied by placing parkway or lead covered cable under ground entirely around the field. Constant current transformer or voltage regulator is used to supply correct voltage, red lights are used in the circuit to indicate buildings or obstacles that may exist on or near the field and the green lights are used to indicate the best approaches or run ways. On some of the smaller or intermediate fields where a lesser number of lights are required one or two mulitple circuits are used where it is not desirable or necessary to use the 2300 volt series circuit.

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*Paper presented at a meeting of The Illuminating Engineering Society, Baltimore Chapter; reprinted from "The Baltimore Engineer" of July, 1927.

A beacon light to guide the pilot to the field is another item of terminal or intermediate field lighting. The common practice is to use a 24-inch drum type which revolves 6 R. P. M. with the beam elevated about two degrees above the horizon. These beacons ordinarily use a thousand watt lamp and operate at 110 volt. A small motor is placed in the base of the beacon to rotate it. These beacons seem to have proven quite satisfactory, particularly on account of the distinctive character of the light which is quite readily distinguishable from other lights that may be adjacent. However, several quite improved types of flashing beacons have been developed and tried out recently with very good results.

A ceiling light is an asset on a terminal field or any other field from which weather reports are furnished. Most any type of projector with a concentrated beam which will reach about two thousand feet is adequate for this work. However, the light should be readily adjustable to a 45-degree angle, by using a simple method of triangulation it is very easy to determine the heighth of clouds at night, the same light may also be used as a work light in case a ship gets stuck out on the field for any reason.

A lighted wind cone or tee is essential on both terminal and intermediate fields, the wind cone (or sock as it is usually termed) is composed of two rings, the larger one about 20 inches in diameter and the smaller one about 10 inches in diameter spaced about 8 feet apart with a fabric covering between, the rings forming the ends of the sock, the large end is mounted to a mast on a swivel and is usually placed on the hangar roof and about 10 feet above the roof to get a true indication. The sock, of course, is free to swing with the wind. Several methods have been tried out for lighting a wind sock, however the most satisfactory method seems to be to place three or four one-hundred watt lamps with ordinary R. L. M. reflectors about 6 feet above the cone, thereby iluminating the top side of the cone so that a pilot in the air has no difficulty in distinguishing the wind direction.

If a wind tee is used it is usually located at some unused spot on the field, a wind tee is usually about 25 feet long with a cross member of about half that length and is usually made up with a triangular section with the point of the triangle upward and a row of lights running along the top of both the main and cross members. A fin is provided at the tail of the main member to keep it headed into the wind, the whole tee being mounted at the C. G. on a bearing which allows it to swivel and head into the wind at all times. The best way to construct a wind tee is to use a thin gage of steel tubing about 1 inch in diameter welded and covered with a light fabric, airplane linen is usually used, doping it and then coloring it a bright orange color which is most distinguishable at night, the same coloring treatment is used on the wind sock.

A brief summary of the lighting equipment essential on a terminal field being a beacon to guide the pilot to the field, flood lighting to light up the ground so as to give the pilot daylight prospective as nearly as possible, boundary lights to outline the field, with red obstruction lights on or near to any buildings or obstructions that may be on or adjacent to the field, with green lights to indicate the best approaches or runways (the red and green lights are usually included in the boundary light circuit), a ceiling light to indicate the height of clouds at night, a lighted wind cone or tee to show wind direction and in the case of the wind cone it also gives a fairly good idea of the wind velocity. There is a great deal that might be said about the details of any one of these items, however the flood lighting of the actual landing area stands out as one of the most important items and is probably the most expensive item of terminal field lighting, so let's consider for a moment the results that we desire to achieve. As I said before, it is desirable to light up the ground to give a daylight prospective as nearly as possible, which, of course, means that an equal distribution of light is desirable. The top of the beam or beams of light should cut off as sharply as possible, in other words, illuminate the ground and not the air above, as it is desirable that a pilot be able to fly above the field at a height of 20 feet or 30 feet and not be in the light at all. The 180 degree flood light gives a ground illumination that is very distinctive from the air. The flat side of the illuminated semi-circle not only outlines the border of the field but gives a definite position with regard to directions and cannot be confused with numerous automobile or locomotive headlights that may be adjacent to a flying field. Always bear in mind that we are talking about commercial night flying on a regular schedule which means that the schedule must be maintained under practically all weather conditions and it is the bad weather conditions that we must consider in lighting a terminal field. Under bad weather conditions the more distinguishable the character of the lighting, the more help it is to the pilot in locating and determining the position of a field, I might state that I have seen several of the air mail pilots land when the fog was so thick that you could not see the plane until after it had landed and taxied up near the hangar, and it is under such circumstances that we should consider our field flood lighting equipment. With average or better weather conditions night flying is not much more hazardous than day flying, however, when poor visibility is combined with darkness it creates an emergency condition which is an important thing to consider.

If we could have an ideally flood lighted field I would say that it should be lighted with sharp cut-off at all boundaries of the field and with a sharp cut-off at a height not to exceed 10 to 12 feet, which would allow a pilot gliding into the field from any direction to know at once when he was over the landing area, as very often landings are made when the visibility is so low that boundary lights are only distinguishable for a very short distance, in fact, only a few feet sometimes. However, if the flood lighting has sufficient intensity and good distribution it will create a glow in the fog or haze over the field which will greatly assist in getting the ship down without damage even when the visibility is very poor. This may seem far fetched to some of you; however, when you stop to consider that about 20 per cent of the mail flights between New York and Cleveland are made above low clouds or fog and out of sight of the ground you will appreciate that it is important to provide lighting equipment which will bring the plane down safely at the terminal field.

Air way lighting between the terminal fields is now being handled by the Bureau of Aeronautics in the Department of Commerce in very much the same way that they handled the lighthouse service. They are placing 24-inch revolving beacons at about ten-mile intervals and intermediate fields about thirty-mile intervals. The intermediate fields are also equipped with boundary lights and a lighted wind cone. They are not ordinarily flood lighted on account of the infrequency of use made of them, and with the improvement that is being made in flying equipment, particularly with the new models of air-cooled engines that are being produced, it may develop that it will not be necessary to have intermediate fields even as closely spaced as thirty miles apart and it probably will develop that beacon lights will be placed at closer intervals than ten miles, because when bad visibility does exist the last place you can seen anything is straight down and it goes without saying that the more lights you can have beneath the plane in flight the more likely that plane is to complete its trip on scheduled time; it does not seem unreasonable that beacon lights along an airway will eventually be placed at intervals approximating the practice of railroad signal lights, which is about a mile apart. These beacon lights not only keep the pilot on his course but they enable him to keep his equilibrium in flight when nothing else is visible except an occasional light. The general concensus of opinion of all pilots is that you cannot fly entirely blind without seeing anything for a period of more than 30 minutes and feel sure of your equilibrium and course of flight. However, just one glimpse of a light allows a pilot to orientate himself and continue on his course.

The Department of Commerce are also providing radio beam along the course and the pilot flying on the course and wearing his ear-phones, gets a long dash when he is in the center of the beam which indicates he is on his true course, if he wanders to either side of the course he gets a different signal, perhaps a dot and a dash at one side of the course and two dots at the other side of the course which signals blend into one long dash when he gets back on the true course. The radio direction beacon will no doubt be of the greatest assistance to the pilot in holding his true course, however, it will tend to encourage blind flying which means instrument flying to retain equilibrium. Instrument flying at night usually means a bank and turn indicator in connection with a accurately compensated compass, with these instruments, and a pilot has had a few years' experience in their use flying blind, he is able to navigate in just as thick weather as a ship at sea might do.

The lighting equipment on the plane is perhaps the best standardized of any aeronautical lighting. It consists of two landing lights or headlights generally similar to automobile practice, however, higher candlepower. The landing lights are usually located just below the wing tips and the custom is to point one light downward to assist in picking up the ground when landing. The other light is pointed straight ahead to assist in picking up any obstruction. These lamps are 25 ampere, 12 volts, 9200 lumens, with beam candlepower about 150,000 current is supplied from either a motor driven generator or a large battery which supplies current for about 45 minutes; these batteries being charged at the completion of each trip. There are also navigation lights which are of 21 candlepower, a red light on the top end of the left wing and a green light on the top end of the right wing and a white tail light which is similar to marine running light practice.

Two parachute flares are also carried. They are manually released by the pilot. The candle automatically igniting about two seconds after release. The parachute maintains decent at about 7 feet per second, dropped at 2000 feet they illuminate a circle with about a mile radius. The candle burns 4 to 6 minutes.

The present stage of aeronautical illuminating might be compared to the lighting equipment of automobiles of about twenty years ago and there is every reason to hope that the illuminating engineers will help solve the lighting problems as most of the development thus far has been made by enthusiasts over aeronautics who had very little actual knowledge of illuminating engineering the co-operation of illuminating and aeronautic engineers need.

The Business Situation

PROSPERITY is not uniform by any means and easy money is not going to offset the difficulty which is faced by many of the smaller Companies in maintaining adequate earnings. Our prosperity at present is very real but highly conservative. The margin of profit has been small, but as compared with previous years production has been large. Last year's steel output was 3,300,000 tons greater than the maximum of war time. A million more automobiles were purchased in the first five months of 1927 than in a similar period of 1922. Railway carloadings during the same months were nearly two million more cars than in 1925 and five million more than in 1920.

The following interesting quotations from correspondents are well worthy attention:

CLEVELAND TRUST COMPANY BUSINESS BULLETIN

COLONEL LEONARD P. AYRES, EDITOR

"BUSINESS continues to be slow but hopeful. The slowness is the result of the gradual decline in the production and marketing of goods that has been under way since last spring. The hopefulness is founded on the generally accepted belief that the current and prospective ease in money rates will bring about rather more than the usual autumn stimulation of industry and trade.

"Industrial profits continue to be irregular and on the average rather persistently smaller than they were during the corresponding months of last year. Commodity prices have given no clear indication of having terminated their long declining trend, but there have been of late a good many individual advances. The aggregate value of new construction projects for which contracts are let each month remains at almost record high levels. It is true, however, that an increasingly large proportion of these contracts is for public works and engineering projects, so that the building industry is distinctly slowed down in most localities, and real estate activity reduced.

"It now seems probable that during the remaining months of the year business will continue to be slow and hopeful. Two sets of economic influences are in conflict; the ease of bank credit, which should operate to stimulate business, and the declining trend of commodity prices, which tends to restrain it. The overabundant credit supply will probably result in still more activity and higher quotations in the security markets, and one byproduct of that is likely to be the generation of a cheerful attitude on the part of business men.

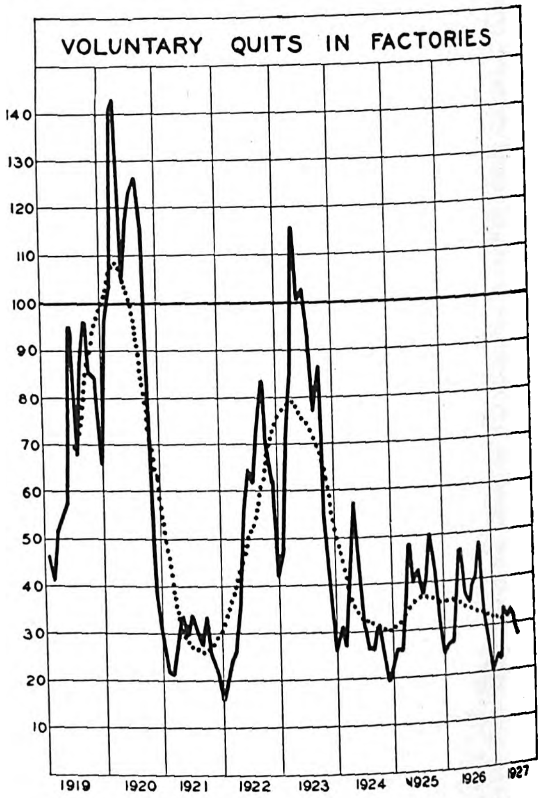
"One cannot be so confident, however, that this period of exceptionally easy credit conditions will bring about in the near future a sustained advance in commodity price trends. The abundance of bank credit seems to have been employed in the past few years by manufacturing industries to improve their mechanical equipment so as to produce greater volumes of goods at less cost. The easy terms for credit are likely, however, to furnish an important sustaining influence for the construction industries.

"It now seems entirely probable that the final figures for 1927 will be somewhat lower than those of 1926 in such highly important fundamentals as the production of iron and steel, the output of automobiles, the volume of building construction, the mining of coal and ore, and the transportation of freight on the railroads. No sharp decline in these or other important lines seems in prospect, but neither are there any present signs of impending sharp upturns.

Voluntary Quits

"Under the leadership of Dr. William A. Berridge of The Metropolitan Life Insurance Company a new type of employment statistics is coming into favor. Each month carefully compiled data are gathered from some 200 important industrial establishments, employing about 500,000 workers. The figures show the changes in the number of employees, the new workers taken on, the old ones discharged or laid off, and the number quitting of their own accord.

"The diagram is based on these latter figures, which are referred to as being those showing the



Courtesy of Cleveland Trust Co.

number of voluntary quits. The irregular line in the diagram shows these figures monthly over the nine year period since the war. The figures have been reduced to a basis of rates, and in this case that means that when the line is at about the 100 level, as it was early in 1920, the workers are leaving their jobs of their own accord so rapidly that if they continue to do so at the same rate for a year the total number of such voluntary quits in 12 months would be equal to 100 per cent of the number of employees in the factories. The figures are really annual rates of voluntary quits in the turnover of factory labor.

"The dotted line is merely a 12 months moving centered average of the same data, which is included in the diagram to eliminate the month-to-month minor fluctuations, and to show how the general trend has run when the incidental and seasonal fluctuations have been removed. Since the war there have been two periods of real competition for industrial labor, when almost any factory worker could leave his job and easily and at once find a new one if he wanted it. The first of these came in 1919 and early 1920. It was followed by the depression of 1921 when jobs were hard to find, and unemployment was serious. The second period when the jobs sought the workers was in late 1922 and early 1923. The lines in the diagram clearly reflect these contrasting conditions.

"During the past two years the rate of voluntary quits has been slowly but steadily declining. It is now about as low as it was in 1924, when industry was distinctly slowed down, and it is nearly as low as it was in the hard times of 1921. Factory workers are now holding on to their jobs with tenacity. This is no doubt in part due to the fact that industry has slowed down enough so that new jobs are hard to find, but it is probably also due in part to better personnel management by which well-run firms try to reduce labor turnover. Each year the rate of voluntary quits has risen in the summer and declined in the winter, but this year the regular seasonal variations seem to be smaller than they have been previously."

THE NATIONAL CITY BANK OF NEW YORK

"THE commonly used measures of business activity continue to indicate the existence of some slack in various branches of production and distribution. Iron and steel and automobile manufacturing are substantially lower than at this time a year ago, and trade generally presents a more uneven appearance than was the case in August last year when a recovery was well under way from a period of hesitation in the Spring and early Summer.

"At the same time it is clear that business in the aggregate continues in very large volume. While factory employment and payrolls and railway traffic have shown some reduction several leading lines of trade reflect large or expanding activity, and industrial consumption of electric power and bank checks cashed throughout the country are running about the same as or slightly higher than a year ago. Definite indication as to the trend of Autumn business is still lacking, but the absence of any fundamentally unfavorable factors affords ground for confidence.

"Unquestionably one principal cause of irregularity is the diminished activity in the automobile industry, caused chiefly by the shutdown of the Ford plants which have been undergoing extensive changes preparatory to the manufacture of new models. This industry has become so important a factor in our economic life by reason of its large employment of labor and consumption of materials of all sorts that any change in its manufacturing schedules is quickly felt over a wide area. For this reason account should be taken of the fact that the present relatively low production in that industry is due partly to temporary causes and may be counterbalanced by increased production later on.

Easy Credit Conditions

"A factor of outstanding importance is the continued ease of money, which has been accentuated by action of the Federal reserve banks in reducing rediscount rates and in making credit more readily available by their purchases of Government securities. While the ultimate consequences of continued easy money are by no means always favorable, the immediate influence is bullish, and any substantial trade recession under present conditions would be contrary to experience.

The Trend of Industrial Profits

"Comment has been made upon the favorable showing of corporation earning statements for the second quarter. Since then additional statements have come out which have failed to measure up fully to the standard of the earlier reports. As a result, out of a total of 168 leading companies whose figures have thus far been tabulated, 90 companies or 54 per cent, now show smaller earnings than were made a year ago, while the combined earnings for all companies likewise fell slightly below those of the second quarter of last year, even with the inclusion of the large gain for the General Motors Corporation. Without the latter's figures there was a decrease of about 14 per cent.

"Bearing also on the question of earnings, though from another angle, are the business failure figures which have been continuing their tendency to increase. For the first seven months of this year, according to R. G. Dun & Co., the increase in number has amounted to 7.4 per cent and in liabilities 35.5 per cent as compared with the same in 1926."

Items of Interest

Standardization Progress

A report of the progress actually made to date in standardization is offered by the Year Book of the American Engineering Standards Committee which has just been issued. An extremely wide range of work is covered, from bolts and nuts to a code for rock dusting coal mines, from specifications for railway ties to standards for methods of recording and compiling accident statistics.

The following table gives a bird's eye view of the status which has been reached in the major lines of work:

Group	Number of projects	Projects approved
Civil Engineering and Building Trades	36	19
Mechanical	61	19
Electrical	39	11
Automotive	4	3
Transportation	10	9
Naval Architecture and Marine Engineering—Shipbuilding.	1	..
Ferrous Metallurgy	9	7
Non-Ferrous Metallurgy	14	10
Chemical	12	10
Textile	3	1
Mining	20	5
Wood	5	3
Pulp and paper	2	1
Miscellaneous	22	5
Total	238	103

The number of projects has increased from 212 to 238 and the number of approved standards from 82 to 103 during the year.

There are now approximately two thousand individuals serving on sectional committees, the accredited representatives of over three hundred national cooperating bodies.

Mechanical Standards:

Substantial progress has been made in the work of bolts, nuts and rivets. One fundamental part has been completed and published, that on wrench-head bolts and nuts. Other parts including slotted head machine screws and wood screw heads, track bolts, and carriage bolts, are well advanced. Most of the work on the nine sections of the project on pipe flanges and fittings is nearly completed and it is expected that several of these will be ready for publication in the very near future. One section, that dealing with high pressure fittings and flanges, has been completed and issued. Even before publication the work has already been of great value to industry, whose practice has now been brought into essentially complete accord with the draft standards. The first section of the work on machine tool elements, that dealing with T-slots, has been completed, as has also the first section of the work on gears, namely, tooth form of spur gears. A specialized but important piece of work completed is that of shafting keys, both plain taper and gib head.

Mining Standards:

In the mining industry, work is in progress on fifteen projects, five of which have already been completed. Recommended practice for the drainage of coal mines, and safety rules for the installing and use of electrical equipment in coal mines have both involved unification of work on these subjects by the Bureau of Mines, the American Mining Congress and other mining organizations. One of the most important projects of those recently approved relates to rock dusting of coal mines to prevent danger of coal dust explosions. Since its adoption insurance companies covering mine insurance have announced that compensation policies will not be issued on gaseous and dusty mines unless they are rock dusted.

Civil Engineering and Building Trades:

More than a hundred million railway ties are produced in this country yearly. During the year specifications satisfactory to both the steam and electric railways have been agreed upon for the first time. It is an interesting illustration of the manifold interrelationships of modern industry that eleven organizations were officially represented on the sectional committee through which this unification of specifications has been accomplished. Specifications for tubular steel poles and for girder rails have also been unified and approved.

The code for building exits, which has involved extensive work on the part of a number of organizations over a period of years, has been completed and issued. The revision of the specifications for fire tests of materials and construction, involving some important changes, has been completed and published. The work on spiral steel rods for concrete reinforcement, as submitted by the National Committee on Metals Utilization, was approved. Notable progress has been made in the work on specifications for cast iron pipe. The work on rating of rivets has reached the stage in which the sectional committee has deemed it desirable to seek formal international cooperation, with a view to bringing about uniformity in the various countries in the world.

Safety Codes:

Twenty-four of the fifty codes on the national safety code program have been approved by the American Engineering Standards Committee. Among those approved during the year are those for the prevention of dust explosions in half a dozen important industries, codes for forging and hot metal stamping, automobile brakes and brake testing, and revisions of the codes for punch presses, and abrasive wheels, and of the gas safety code.

A particularly important development has been the revision of the "National Electrical Code," which is the industry's bible for wiring devices. This included a settlement, by almost unanimous action, of the controversy of three years' standing, over the admission, as approved material, of non-metallic sheathed cable. This new material was approved for limited uses.

In connection with the safety code program, and upon the initiative of the state industrial commissions, arrangements have been made for the revision of the standard plan of reporting and compiling accident statistics under the procedure of the American Engineering Standards Committee. This plan forms the general basis of the accident statistics of the various state governments and of the casualty insurance companies.

Recent formal requests for new undertakings relate to face to face dimensions of flanged valves, plumbing equipment, screw threads for rigid electrical conduits, speeds of driven machinery, trimmed paper sizes, and specifications for household refrigerators.

A copy of the Year Book will be sent upon request to **Engineers and Engineering.**

Street Lights of Entire City Are Controlled by Vacuum Tube Transmitter

A long-wave, low-powered vacuum tube transmitter, similar in many respects to the familiar radio transmitter, operated 15 seconds daily, now controls all of the street lights in the city of Glens Falls, N. Y., the system of carrier current control having been inaugurated in September, marking the first commercial application of the system. In this system, developed by engineers of the General Electric Company, the radio or electromagnetic waves, instead of spreading out in all directions as do radio waves from the antenna when used for communication purposes, are confined to the wires to receiving stations. There switches are tripped, relays operated, and lights controlled.

The operation of the transmitter on the high frequency of 40 kilocycles, or about 7,500 meters wavelength, prevents any interruption with broadcast reception, even during the few seconds the carrier current apparatus is in operation.

The successful application of carrier communication to power circuits suggested the possibility of applying similar methods for the remote control of apparatus. Among the methods of control that have been or are being used are the following: Manual control, frequency variation, "flashing," superposition of frequencies of from 200 to 1000 cycles on the power wires, time switches, cascading and pilot wires. Most of the effort has been directed toward placing the control in the hands of a substation operator, and in some way utilizing the existing power wires for extending the control from the substation to the lighting circuit.

In applying carrier current control to the remote control of an automatic constant-current transformer supplying a street lighting circuit, a carrier-frequency generator is located at the substation and coupled to two phase wires or to a phase wire and neutral, through condensers and drainage equipment. The coupling condensers have a very high impedance to the power frequency and allow only a very small power-frequency current to flow. The drainage coils offer a high impedance to the carrier frequency but practically short-circuit the low-frequency potential on the side of the condensers to which they are connected. The control apparatus is thus completely separated from the power circuit. There is no danger to the operators of contact with the power circuit and, since the insulation on the coupling condensers is as good or better than that of the other apparatus connected to the feeder, there is no additional hazard to continuity of service by reason of the control equipment. Since the condenser reactance is high to the power frequency, there is in effect no ground placed on the system.

The receiver is coupled to the same two wires as the transmitter, at the point at which it is desired to locate the transformer. The coupling method is the same as at the transmitter. The contactor and constant-current transformer are the same as used with manual or time-switch control. The receiver takes its power from a convenient secondary circuit, no batteries being required. When it is desired to turn on the lights at the remote point, the "On" control switch is turned and released. This starts up the carrier transmitter and sends out a control impulse of definite duration. To turn the lights off, an opening switch is operated in a similar way, sending out a control impulse for a different length of time from that for the closing operation. In either case the transmitter is automatically shut down after the impulse has been transmitted.

The advantages of carrier control are summarized briefly as follows:

Existing circuits are used for transmission of control energy.

The usual distribution of power is not affected in any way.

Interference with telephone and space radio is avoided.

The control is equally applicable to grounded or ungrounded distribution systems.

It is not operated by lightning, switching surges, or stray currents.

The "On" and "Off" operations are distinctive, so that there can be no question as to the condition of the circuit at the remote point.

A temporary loss of power does not affect the condition of the controlled circuit.

Tracyfiers Are Now Made in Pittsburgh

The Tracyfier (formerly known as the Tracy Steam Purifier) was originally designed exclusively for marine use. In its first form, it was installed in many hundreds of ocean-going steamships, where it proved uniformly successful. Its adaption to land boilers, however, required a vast amount of research and experimental work which resulted in the development of the Tracyfier to its present state of high efficiency.

Since the purchase of the Tracy Engineering Company by the Andrews-Bradshaw Company, the factory has been moved to Pittsburgh. The location of the factory in Pittsburgh gives an opportunity to continue the development and research work on a far greater scale than formerly. Considerable research work is under way at the present time relating to the use of the Tracyfier principle for the cleaning of gases other than steam. Much work has already been done along this line, and the Tracyfier has been extensively used in the cleaning of natural gas and in the separation of various liquids from their vapors, principally in oil refineries.

High Frequency Electric Induction Furnaces

These furnaces for large scale production are now in use with melting capacities ranging from 100 to 400 pounds for ferrous metals and up to 900 pounds for non-ferrous alloys, operated from motor generators. They are being used for large scale commercial melting of nickel-silver, special steel alloys, nickel-iron, copper and various special alloys under specially controlled conditions of purity and temperature control not to be found in any other form of melting equipment.

Simply explained, these furnaces consist of a crucible surrounded by a copper coil which, having no contact with the crucible, heats the metal placed inside by electrical induction. As the heat is generated only in the contents of the crucible, the metal is said to "melt itself," being vigorously stirred meanwhile by the electrical current flowing in it.

This electrical, automatic stirring insures homogeneous alloys and reduces greatly the time required for slag treatment of steels.

Besides the very obvious advantages of freedom from carbon, ease of temperature control and comfortable working conditions, there is one feature of high frequency heating that has great importance—and that is the almost unlimited speed of melting which it is possible to reach. This high-speed heating increases the melting efficiency for the following reasons:

1. Very little heat escapes from the furnace during the progress of the melt.
2. The inductor can be brought very close to the melt, as little refractory between the melt and the coil is required.

Acid Extraction Processes for Obtaining Aluminum from Clay

Studies for the development of acid extraction processes leading to cheaper methods for the obtaining of aluminum metal from clays and other aluminum silicates, which are very abundant in nature, have been completed by investigators of the United States Bureau of Mines, Department of Commerce. The amount of low-silica bauxite, from which aluminum is at present principally obtained, available at low cost in the United States, is not large, and imports of bauxite used by the American aluminum industry are increasing. Many power sites of the western Intermountain region could produce aluminum cheaply if a satisfactory source of aluminum oxide were available.

With this situation in view, the Bureau of Mines decided to make a study of acid processes of extracting alumina. Acid processes do not suffer from silica contamination in the same way that the Bayer process does, and consequently they can be applied to the siliceous bauxites now unused by the Bayer process. On the other hand, these processes would have difficulty in handling the high-iron bauxites suitable for the Bayer process. On that account the acid processes need not compete with the Bayer process for raw material. Kaolin, alunite, leucite, glauconite, and other minerals suitable for acid decomposition are widespread; acid plants for producing alumina need not be restricted to a few localities, as those using the Bayer process now are.

The exact proposal studied by the Bureau of Mines was to treat a clay, alunite, or other material capable of decomposition by sulphuric acid, and then dissolve the resulting aluminum sulphate in water, the water being kept at the minimum in order to avoid excessive evaporation later in the process. This aluminum sulphate solution contains as its main impurities iron, titanium, and silicic acid. Alkali metal sulphates are also present. By neutralizing the excess acid the silica, titanium, and iron compounds by proper manipulation can be successfully thrown out of the solution and the resulting aluminum sulphate solution is ready for sedimentation, filtering, or other treatment to separate the impurities. This solution can then be evaporated and crystallized. The alkaline sulphates form alums which tend to crystallize before the aluminum sulphate does. Spray drying of the solution is also possible. The aluminum sulphate crystals contain much water of crystallization which must be properly eliminated; the resulting "burnt alum" can then be calcined at such a temperature that it will be dissociated thermally into aluminum oxide and the oxides of sulphur. The gases containing the oxides of sulphur are to go back to a sulphuric acid plant for return to the process. The only sulphuric acid consumed in the process is that lost mechanically and that which combines with the alkali and alkaline earth metals present in the raw materials.

Further details are given in Bureau of Mines Bulletin 267, "Acid Processes for the Extraction of Alumina," which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of 15 cents.

The following letter has been received with reference to the above:

"The development of a process to extract the alumina from clay has been the chemist's goal and promotors downfall ever since aluminum became an important metal. The various aluminum companies have spent a great deal of money on investigations and in trying out patented processes. So far, experiments seem to have yielded very little in the way of economic results. There are a number of processes that work perfectly from a technical standpoint but the cost of production is so much higher than present methods that they are out of the question.

The only processes that seem to hold out promise of commercial success are the ones where the alumina is a by-product and the major product is able to carry the cost of production.

There is any quantity of low silica bauxite, but it is outside of the United States and the deposits that are near transportation are controlled by the large interests.

Dalmatian bauxite can be purchased c. i. f. New York at from \$5 to \$6.50 per ton. Crude Kaolin, or china clay, costs about the same. The bauxite contains from 55 to 60% alumina (aluminum oxide) in a soluble form, the clay contains from 30 to 36% in a very insoluble one.

I think the above announcement is of general interest but feel that the wording of it is rather too optimistic."

L. T. E.

Determining the Amount of Daylight

By combining new equipment with an old principle, a device which records the amount of daylight received over any desired period of time has been developed by Dr. L. R. Koller of the research laboratory of the General Electric Company.

The new equipment is a giant photoelectric cell, several times larger than the usual cell and two hundred times as sensitive. The old principle is the one discovered by Michael Faraday many years ago, that a given quantity of electricity will always release a definite quantity of hydrogen if passed through a conducting solution.

The Daylight Integrator, as the new device is called, consists of the large photoelectric cell, a 45-volt "B" Battery, a sensitive ammeter for instantaneous daylight measurements, and an electrolytic cell such that the hydrogen released at the negative electrode is collected in a narrow, upright tube.

The photoelectric cell is a gas-filled glass bulb (in this case seven inches in diameter) which is coated on the inside with a light-sensitive alkali metal. This mirror-like coating entirely covers the inside surface of the bulb except for a circular area which serves as the window for the entrance of light. The coating is used as one electrode of the tube; metal plate standing upright in the center of the bulb, and insulated from it, serves as the other.

If a battery is connected in series with the photoelectric cell and an ammeter, with the positive terminal of the battery connected to the metal plate within the photoelectric cell, the ammeter indicates no flow current if the cell is kept in the dark. If light is permitted to strike the window of the cell, however, the ammeter shows that a current is passing through the circuit, and that the amount of current is proportional to the intensity of the light. The light which strikes the sensitive metal coating on the inside of the bulb causes the release of electrons—unit particles of electricity or matter. These electrons jump across the vacuum between the metal surface and the other electrode, thus permitting a flow current.

If one desires to know the intensity of the light at the instant, it is apparent by the reading of the ammeter, provided the sale has been so marked as to indicate average daylight, etc.

By adding an electrolytic cell in series with the battery, photoelectric cell and ammeter, it is possible to determine the total amount of daylight received each hour, day or week.

A glass beaker containing a weak acid solution is used as the electrolytic cell, and a carbon rod as the positive electrode. A copper wire projecting up under a long glass tube, and so insulated that only the part of the wire directly under the tube can be reached by the solution, serves as the negative electrode. When an electric current is passed through this cell the water is broken down into its constituent elements—two parts by volume of hydrogen and one of oxygen. The small amount of current which the photoelectric cell permits to pass through the circuit releases tiny bubbles of hydrogen on the surface of the copper wire. These break away from the wire and rise in the tube, slowly forcing the water downward in the tube. The effect is the same whether a small amount of light is received over a long period of time or a large amount of light for a short time—provided the total amount of light received is the same, the amount of hydrogen liberated will be constant. Depending on the diameter of the collecting tube, the height of the water column will vary. In Dr. Koller's laboratory equipment the tube has a diameter of about one-eighth of an inch, and the light received during an average clear day will force the column of water down about five inches—a rainy day will cause a drop of only one inch. By recording the height of the water at the end of each day, and by refilling the column with water each morning, it is possible to obtain a comparison of the daylight from day to day.

Still another way of determining the amount of daylight is by the use of a recording ammeter, a device which charts a line indicating the amount of current as the intensity of the light varies from time to time.

The photoelectric cell, one of the newest members of the vacuum tube family, is finding applications in many fields of research and industry. It has been put to work in many ways to replace the human eye as an accurate judge of colors and of light intensities, such as in a cigar grader in which it separates cigars according to the color and shade of the wrappers. Similarly, it is being used in radio transmission of pictures and in talking motion pictures, to mention but a few of its many uses.

CHEMICAL ACTION OF ALKALI ON HYDRAULIC CEMENTS—TRANSMISSION OF WHEEL LOADS TO CULVERTS—CONCRETE CRADLES FOR LARGE PIPE CONDUITS

The Engineering Experiment Station of Iowa State College will send copies of its bulletins free upon request. The following have recently been published:

THE CHEMICAL ACTION OF ALKALI ON HYDRAULIC CEMENTS is the subject of a 56-page illustrated bulletin (No. 74). Experiments were carried out on portland cement and high alumina cement, using magnesium sulphate, magnesium chloride, sodium sulphate, sodium chloride and sodium bicarbonate solutions. It was found that a magnesium sulphate solution had the greatest destructive action on concrete and next to that, sodium sulphate.

Formulae for the TRANSMISSION OF WHEEL LOADS TO CULVERTS through various thicknesses of cover are included in No. 79, an 80-page illustrated bulletin having the title of Experimental Determinations of Static and Impact Loads Transmitted to Culverts. This bulletin is the result of a 3-year highway research investigation conducted in cooperation with the United States Bureau of Public Roads.

A 44-page illustrated bulletin, No. 80, deals with CONCRETE CRADLES FOR LARGE PIPE CONDUITS. This investigation also was conducted in cooperation with the United States Bureau of Public Roads. The bulletin deals with the action and effectiveness of cradled concrete pipe from 24 in. to 80 in. in diameter.

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Estimating Building Costs—By Frank E. Barnes. 2d edition. 592 pages, 4½x7 inches, illustrated. $5.00.

From excavation and foundation work right through to the wiring and painting of the finished buildings, the book gives exactly the information needed to insure safety in the estimate from every point of view. It tells you how to calculate the cost of materials, of labor, of haulage, of overhead, of equipment and so on. It gives valuable information on installations and material strengths.

All the material in this second edition reflects latest conditions. Much new matter has been added, but the book retains its convenient size because of the summary and tabulation of less important information. The book gives the amount of labor required at the present time to perform the various kinds of work described. All building material prices given have been revised to date.

The chapter on Concrete gives the latest practical method for determining the most efficient mix. This has been written from the point of view of the man on the job.

The chapter on Structural Steel has been fully rewritten by Mr. Robins Fleming and is of real value to those estimating the cost of structural steel.

A new chapter on Metal Store Fronts has been added.

Fundamentals of Electrical Designs, by A. D. Moore, Assistant Professor of Electrical Engineering, University of Michigan. 355 pages, 6x9, 124 illustrations. $4.00.

A clear, well-organized presentation of those fundamental principles of electrical design which all electrical engineers must know, without the detailed design procedures which only electrical designers need. The book is an excellent survey of electrical principles for electrical engineers who do not care to specialize in electrical design.

Using Radio in Sales Promotion—By Edgar H. Felix, Broadcasting and Merchandising Consultant, Contributing Editor, Radio Broadcast; Member, Institute of Radio Engineers. 386 pages, 6x9, 43 illustrations. $5.00.

A detailed consideration of the principles and practice of using radio broadcasting effectively to secure the utmost in public good will. The subject is discussed from every conceivable angle, from who should use the radio medium, estimating a radio feature's audience, and what the qualities of a successful good-will program are, to the relation of broadcasting to advertising and publicity, the changing structure of commercial broadcasting, and forecasting the future of the new medium.

Stream Gaging, by William A. Liddell, Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology. 239 Pages, 6x9, illustrated. $3.00.

This book presents briefly such theories of stream-flow as bear on the subject of stream gaging; considers practical means for applying these theories to the measurement of flow; examines the characteristics of the various measuring devices, and outlines methods for the analysis of stream-flow data.

Electric Elevators—By F. A. Annett, Assistant Editor, "Power." 437 pages, 6x9 inches. 351 illustrations. $5.00

A sound, practical discussion of the design, construction, operation and maintenance of electric elevators of all types for engineers, architects and building superintendents.

American Society of Heating and Ventilating Engineers' Guide, 1926-27. Containing Design and Specification Data Useful in the Planning and Construction of Modern Heating and Ventilating Installations. Prepared from the Society's Transactions, Investigations of Its Research Laboratory, and the Practice of Its Members. Together with a Manufacturers' Catalog Data Section, Containing Essential and Reliable Facts Concerning Modern Equipment, and a Consulting Service Section for Engineers. Also the Roll of Membership of the Society with Complete Index of Technical and Catalog Data. Volume 5. Cloth, 6x9, $3.00 per volume.

The fifth edition of this valuable reference data book published annually for engineers, architects, and contractors has been mailed to all members of the Society.

This is the biggest Guide ever published—several new chapters appear and the other sections have been amplified with new material. For the first time, Air Conditioning, Drying, Mechanical Draft, Ozone, and Building Insulation have been treated thoroughly and in addition new data have been given on Greenhouse Heating, Water Supply Systems, Boilers, Oil Burning, and Gas Heating. The result of further laboratory research has produced new tables on heat, humidity, and air motion, as well as a new comfort chart.

A new index to the technical data section is an added feature that will make the book more useful.

Weights and Measures Laws—The subject matter includes: Federal laws and regulations relating to fundamental standards, marking the net quantity on food packages, standard containers for grapes, fruits and vegetables, standard lime barrel, standard barrel for fruits and vegetables, and weighing livestock; also State laws relating to Babcock test for milk and cream, bottles for the sale of milk and cream, containers for the sale of fruits and vegetables, flour and other mill products, feeding stuffs, fertilizers, etc., inspection of weights and measures, powers and duties of officials, legal rules for the measurement of flowing water, logs, and hay in the stack, marking the net quantity on package goods, sale of bread, coal, wood, and various other articles, standards and units of weights and measures, and weights per bushel of various commodities.

The scope of the laws contained in this compilation and the wide application and interest which weights and measures have, in general, to the conduct of business, make this compilation a very valuable reference work and guide to a large number of different lines of business, as indicated by the variety of the subject matter outlined above.

Bound in buckram, 6 by 9 inches, containing 976 pages, price $2.30. Copies of the compilation, known as Miscellaneous Publication No. 20, Federal and State Laws Relating to Weights and Measures, may be obtained from **Engineers and Engineering.**

Principles of Mercury Arc Rectifiers and Their Circuits—By David C. Prince, Research Engineer, General Electric Co., and Francis B. Vogdes, Research Laboratory, General Electric Co. 233 pages. 6x9, 155 illustrations. $3.00.

The first part of this book begins with a discussion of the physics of several simple types of rectifiers and ends with the mercury arc rectifier. No attempt is made to describe all the various types of rectifiers which are in use. The principal object is to give as clear an explanation of the action of the mercury arc rectifier as possible, and the other rectifiers which are discussed are considered because they illustrate in a striking manner certain phenomena occurring in the mercury device. The second part of the book deals, in the main, with the involved problems which predominate in high-power rectifier practice.

Concrete Practice—By George A. Hool, Professor of Structural Engineering, University of Wisconsin, and H. A. Pulver, Associate Professor of Structural Engineering, University of Wisconsin. 369 pages, 5x8 inches, illustrated. $3.00.

This book covers every important branch of practical concrete work and describes how each operation is best performed in current practice.

The first chapter deals with fundamental considerations of cements, mortars, aggregates, etc. The second chapter takes up the various methods of proportioning, mixing and placing concrete and indicates the best procedure to follow to meet particular conditions.

The chapters following explain the best current practice in preparing contracts, specifications and plans, estimating, inspecting, sampling and testing materials and doing the actual work on concrete basements, sidewalks, curbs and gutters, pavements, tanks, steps, window sills and lintels, floors, culverts, buildings, slab and girder bridges, and arch bridges.

Aerodynamics—By Edward P. Warner, Member, Society of Automotive Engineers; Associate Fellow, Royal Aeronautical Society; Professor of Aeronautical Engineering, Massachusetts Institute of Technology; Appointed Assistant Secretary of the Navy for Aeronautics, July, 1926, 600 pages; 6x9; 333 illustrations. $7.50.

The object of the book is to serve the requirements of airplane design, though the topics treated are not uniformly characterized by immediate availability of practical application. Matter of abstract or academic interest is introduced where, but only where, it will round out the picture of aerodynamic development and where it will aid the reader in regarding aerodynamic phenomena, not as a group of disconnected results of disconnected tests, but in the aggregate.

Mechanics of the Gasoline Engine—By H. A. Huebotter. 313 pages; 6x9; 153 illustrations. $4.00.

A presentation of the principles of engine design that will aid the designer to lay out an engine that is structurally correct, i. e., the parts of which are proportioned for the loads that will be put upon them and constructed of the proper materials. Fundamentals of design are emphasized throughout.

Every part of the gasoline engine with the exception of the carburetor and the ignition system is analyzed thoroughly from both the functional and the structural viewpoint. As an aid in the preliminary laying out of an engine, the essential points of each chapter are summarized at the end.

Civil Aviation—A Report—By the Joint Committee on Civil Aviation of the U. S. Department of Commerce and the U. S. American Engineering Council. Foreword by Herbert Hoover. 189 pages; 6x9; 31 maps and diagrams. $2.50.

This report presents a summary of the facts on the status of civil aviation in this country and abroad, together with a series of recommendations for the promotion of civil aviation in this country. The transportation of passengers and merchandise by aircraft is discussed exhaustively. The report shows what has been done in Europe as well as in the U. S. to develop regular transportation routes, what present problems are and what can be done to promote air transportation.

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ACCOUNTANT ENGINEER.—One with education and experience in accountancy and general engineering, covering production costs, etc. Box E-1377.

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CONSTRUCTION ENGINEER, graduate civil engineer having experience in steel and reinforced concrete construction of varied types. Desires to locate with reputable firm as Superintendent in charge of work. Box A-1041.

EXECUTIVE, graduate engineer, five years' manufacturing experience, specializing in production and material control. At present employed but desires increased opportunity and responsibilities. Box A-1042.

SALES ENGINEER, age 28, graduate, University of Pittsburgh, in petroleum engineering, desires connection with organization selling product of any kind or will take position as junior engineer. Box A-1043.

STRUCTURAL STEEL DESIGNER AND DETAILER. Ten years' experience on mill buildings, power houses and plant work. Position in Philadelphia or vicinity. Box A-1044.

CIVIL ENGINEERING ASSISTANT. Age 28, experienced in surveying, levelling, preparing plans and laying out drainage, water supply and road schemes. Desires connection. Box A-1045.

ARCHITECT'S SUPERINTENDENT, or assistant superintendent of construction, is open for position. Age 37, fifteen years' experience, three years C. E. at Lehigh University. Box A-1046.

GRADUATE ELECTRICAL ENGINEER. Age 31. Married, mechanically inclined. Five years' general experience in telephone plant. At present engaged in development and teaching of training courses. Available October 15. Box A-1047.

CONSTRUCTION ENGINEER. Age 29, wide experience in erection and construction, building material plants, conveyors, elevators, screens. Prefers connection as plant engineer with some industry in Philadelphia territory. Have operated plants of above nature. Box A-1048.

YOUNG MAN, age 22, taking course in Municipal Engineering at Drexel Evening School, is open for position—surveying, or anything along engineering lines. Box A-1049.

MECHANICAL ENGINEER, 19 years' experience in punch and die design on hydraulic and sheet metal stampings. Age 35, married. Would consider any other work on similar lines. Box A-1050.

SALES ENGINEER, age 26, desires connection preferably in the electrical line. Or will take other electrical engineering work. Graduate Drexel Inst., electrical engineering. Box A-1051.

SALESMAN, with several years' practical mechanical experience, desires connection selling or demonstrating. Box A-1052.

TECHNICAL GRADUATE, class 1923, age 26, four years' machine shop experience, three years' drafting and combustion engineering, desires operating or efficiency engineering position. Box A-1053.

ENGINEER, age 36, wishes position with concrete firm, designing, drafting or foremanship, etc. Box A-1054.

DRAFTSMAN, young man 20 years old, desires a position as a draftsman, preferably structural steel work. Three and one-half years high school and two years at Drexel Evening School. Two and one-half years' experience. Box A-1055.

MECHANICAL ENGINEER, age 31, technical graduate. Six years' experience designing piping systems, boilers, heating and ventilating systems and writing specifications for mechanical equipment of buildings. Also some estimating experience on above work. Box A-1056.

CIVIL ENGINEER, graduate Penn State, 1921, desires position in civil or mech. eng. line, purchasing, time, etc. Experience covers inspection, plant maintenance and construction, etc. Box A-1057.

ELECTRICAL ENGINEER, graduate E. E., '27, desires position as junior electrical engineer with electrical construction concern. Position must have future. Location anywhere. Box A-1058.

MECHANICAL ENGINEER, with four years' experience in maintenance, supervision, production control, design and testing of light high speed machinery, desires position along similar lines. Box A-1059.

CIVIL AND MECH. ENG., desires position with reliable engineering and construction company doing power house and general industrial building work complete. 18 years' experience, any location, married, references furnished. Box A-1060.

DRAFTSMAN, young man 25, taking Mech. Eng. Course, with four years' exp. tracing and detailing in struc. steel and concrete; also Mech. Drafting, desires position with opp. for advancement. Box A-1061.

MECHANICAL ENGINEER, graduate of M. I. T., two years' experience in machine design and checking. Desires connection as sales proposition man for special engineering work. Box A-1062.

GRADUATE M. E., age 27, 1½ years transmission, line, survey and const. exp.; also some coal gas plant and reinforced concrete exp. Desires permanent connection in Philadelphia or vicinity. Box A-1063.

MECHANICAL AND ELECTRICAL ENGINEER, age 28, four years of engineering, Univ. of Pa., four years of scheduling, planning and estimating, production and installation work. Desires permanent position with reliable concern. Box A-1064.

CONSTRUCTION ENGINEER, age 29, single, seven years' experience of foundations, wharves, buildings, sewers and highways. Experienced in inspection and reports. Box A-1065.

GRADUATE CHEMICAL ENGINEER. Young lady desires position as secretary-stenographer where technical training will be of value. Experience on correspondence and preparation of reports in general chemical engineering and motor fuels. Box A-1066.

ELECTRICAL ENGINEER. Young man, 27, with eight years' practical experience, now in third year of course in Electrical Engineering at Drexel Evening School, desires position of responsibility in construction or maintenance work. Box A-1067.

YOUNG MAN, 21 years of age, desires position as draftsman. Now taking course at Spring Garden Institute in Mechanical Drawing. Two years' experience in machine work. Box A-1068.

SUPERINTENDENT OF CONSTRUCTION on power plants, power piping and equipment, or industrial or process piping work of any kind. Over 25 years' experience. Box A-1069.

ELECTRICAL CONSTRUCTION ENGINEER. Experienced in installation of sub-stations, plant maintenance, electric furnace and industrial electrical installation. Box A-1070.

YOUNG MAN, 26 years of age, trained and experienced in building construction, surveying and drafting, desires permanent position with local builder or surveyor as supervisor in field or draftsman. Box A-1071.

ELECTRICAL ENGINEER, age 30, graduate, desires position in sales department of electrical manufacturing company, willing to travel. Capable of acting as assistant construction superintendent or assistant office manager. Box A-1072.

PLANT ENGINEER, 35 years old, married, desires position in charge of operating and maintenance in industrial plant. Familiar with A. C. and D. C., steam boilers, turbines, etc. Ten years' experience. Box A-1073.

ENGINEER, CIVIL OR CONST. College graduate, seven years experience general engineering field and office, desires permanent connection with chance of advancement. References. Box A-1074.

STRUCTURAL DRAFTSMAN AND DESIGNER, young man 25, graduate U. of P. Civil Engineering 1924, desires position as structural designer on steel or concrete. Three years experience with architect and consulting engineer. Box A-1075.

CIVIL ENGINEER, graduate of Penn State 1926. Young man 26, desires Civil Engineering work of any kind. Three years experience, inspection and checking of underpinning, etc. Box A-1076.

CONSTRUCTION SUPERINTENDENT or foreman, road work preferred, location secondary importance, service in South America or United States possessions welcomed. Experienced surveyor, good draughtsman. 22 years practical experience. Box A-1077.

CIVIL AND MECH. ENG. University graduate, with 18 years experience, covering construction, erection of turbines and heavy machinery, factory production, bridge work, etc, desires outside position of any kind. Box A-1078.

GRADUATE MECHANICAL ENGINEER familiar with steam power plant practice. Age 28, single, would consider position in sales work or work of a technical nature. Box A-1079.

INDUSTRIAL ENGINEER. Graduate M. I. T. Experienced in planning and scheduling—equalization and distribution of work. Groups bonus systems on labor and equipment and production layout. Box A-1080.

YOUNG MAN, (22), two years, 6 months schooling in Civil Engineering, desires position as transitman, inspector or half time field half time drafting position. 2 years practical experience. Salary desired $125.00 month. Box A-1081.

GRADUATE MECHANICAL ENGINEER, age 26, with drafting and engineering experience leading to sales, desires position with manufacturing company or sales organization with opportunity for advancement. Box A-1082.

MECHANICAL ENGINEER, 29 years of age; seven years experience in sales, production and consulting engineering; covering factory management, cost reduction, increased production, etc. Box A-1083.

MECHANICAL DRAFTSMAN, desires position, layout detail and construction of medium and heavy machinery. Twelve years experience in marine, mining and thrust bearing. Available at short notice. Box A-1084.

STRUCTURAL ENGINEER, eight years experience in both steel and concrete design, desires connection. Box A-1085.

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The Bureau of Standards*

By DR. GEORGE K. BURGESS
Director, Bureau of Standards, Dept. of Commerce, Washington, D. C.

I AM going to speak this evening briefly on two subjects, first, on the National Screw Thread Commission, and second, on the Federal Specifications Board, both illustrations of the Government's work in standardization or in co-operation with others. I think it particularly fitting to speak in Philadelphia of the Screw Thread Commission, because the first screw thread series, which is still current, was established by a Philadelphian, William Sellers, under the auspices of the Franklin Institute in 1861.

The National Screw Thread Commission

The National Screw Thread Commission was established by Congressional action. It was established primarily for use by the government itself in the standardization of screw threads. The importance of the subject to the Government, I may emphasize to you by stating that the Ordnance Department has in storage at the present time some thirty million dollars' worth of gages for ordnance material, so that for that department alone you can see its importance.

An act of Congress, approved July 18, 1918, authorized the Commission with an original term of six months, which has since been extended twice and then, finally, on April 16, 1926, the Commission was established as a permanent body without time limit. The Commission is composed of nine members. The Director of the Bureau of Standards is ex-officio Chairman of the Commission. The other eight members are selected as follows: Two from nominations made by the American Society of Mechanical Engineers, two from nominations by the Society of Automotive Engineers, two from the U. S. Army and two from the U. S. Navy. As set forth in the act, the duties of the Commission are "to ascertain and establish standards for screw threads." The three secretaries—of War, of the Navy, and of Commerce—approve the findings of the Screw Thread Commission. Then it is provided in the act that the Secretary of Commerce shall promulgate such standards for use by the public and cause the same to be published as a public document. In other words, the signature by the Secretary of Commerce implies his endorsement of the standards for use by industry.

The Screw Thread Commission in no sense wishes to arrogate to itself any unique or sole jurisdiction over the subject of screw threads. It is interested only in securing uniformity, both for Government use and, so far as it can lend its efforts and the strength of its prestige, for industrial benefit. The fact is, since the establishment of the Screw Thread Commission, the activity in the screw thread field and the desire for uniformity has become greater and greater. The Commission has published two reports, the first a progress report in 1921 and the second, a revised report in 1924. The reports of the Commission have been prepared after an extensive study of manufacturing conditions and equipment and the needs of industry, and they represent what is regarded by the Commission as the best American Screw Thread practice. That the standards set up by the Commission represent fairly well the needs of industry is evidenced by their wide acceptance and satisfactory use.

The first and most important work of the Commission, after collecting its original information, was the setting up of two series of threads, a coarse series and a fine series, and a complete classification of fits, from loose fit intended for the roughest kind of threaded work to the close fit for precision work. Definite dimensions and tolerances, for each standard size and all fits, are set up in the form of convenient tables. The coarse thread series has pitches corresponding to the Sellers or U. S. Series for ¼-inch and above. Below ¼-inch this series is practically the A. S. M. E. Machine Screw Series with certain special pitches omitted.

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*Paper read before Engineers Club of Philadelphia, March 15, 1927.

The fine thread series is practically the S. A. E. series, supplemented below ¼-inch by the A. S. M. E. Fine Thread Series. In connection with the two thread series established by the Commission, one point worthy of mention is the elimination of the overlapping which formerly occurred between numbered and fractional sizes above ¼-inch diameter. The numbered sizes above No. 12 were so nearly the same in diameter and threads per inch as the fractional sizes as to cause much confusion and an unnecessary duplication of sizes. All numbered sizes above No. 12 have now been eliminated from catalogs and stocks.

Simplification of Die Heads and Chasers

There are several items in which the Commission has been particularly interested. I do not mean by that, that the Commission has handled the subject alone; quite the contrary. Our practice is to call meetings of the interested parties and hold hearings in different parts of the country and get the concensus of the industry. If there is a concensus, or if we can develop a concensus, we encourage the industry itself to agree on what it wishes, and then make sure that the industry fits its program into the program laid down in principle.

Following the lead of manufacturers of machine screws, the manufacturers of threading tools for the larger sizes also agreed to eliminate many of the special diameters, pitches and thread forms which were formerly carried in stock. This action by manufacturers of die heads and chasers resulted in a corresponding reduction in the number and variety of limit gages necessary for the production and inspection of threaded work.

While the Commission has concerned itself primarily with the threaded product, a certain amount of attention has been given necessarily to threading tools and gages, tap drill sizes, and similar problems, although we recognize as a Commission that that is not our primary job. At the present time the Commission is actively cooperating with a large and representative committee, composed of manufacturers and users of taps, in an attempt to establish suitable dimensions and tolerances for these important tools, so that, when these are used under normal conditions, a product will be produced that will meet the dimensional specifications set up by the Commission. The Commission has cooperated with the engineering societies, the Federal Specifications Board, and industrial standardizing committees, and the standards thus agreed upon are coming into increasing use.

Fire Hose Thread

The work of the Commission with reference to fire hose threads consisted in the working out and adopting of definite dimensions and tolerances for the National Standard which had nominally been in use for several years but which had not been interchangeable because of lack of suitable tolerances.

Pipe Threads

The Pipe Thread Standards included in the report were adopted by the Commission in 1919 as they had been prepared and approved by a special committee of manufacturers and users of threaded pipe.

Cooperation with the American Petroleum Institute

The American Petroleum Institute is very active on standardization work and the Commission has cooperated with it in standardizing the thread on casing pipe, drill pipe, and other threaded products used in the oil industry. That industry was in a chaotic condition two or three years ago and trying to match their equipment was a very expensive proposition. The cost of their material often runs into several hundred thousand dollars for one well.

Future Work of the Commission

The Commission now has several projects partially completed and a new report will be necessary soon. This will contain additional information in the form of appendices covering special projects. Among these may be mentioned:

(a) Special threads for electrical fixtures and fittings.

(b) Threads for cutting and welding torches.

(c) Threads for gas cylinders and metal drums.

(d) Instrument threads.

(e) Dimensions and tolerances for taps.

And then at our last meeting we had some of the watch manufacturers present, who want their screws standardized, and that is going to be some problem.

The Federal Specifications Board

This was not established by Congress but, indirectly by executive order, by the Director of the Bureau of the Budget, in October, 1921, through an officer whom we call the Chief Coördinator, whose job it is, so to speak, to unify things in the government service without interfering too much with the operation of the separate departments. In the case of standards, it was found that a considerable amount of chaos existed. Each bureau and each department, sometimes, and even each subdivision of each bureau would have its own specifications for things that might be nominally the same thing. As a result of that chaos, it was decided, under President Harding, to set up a Special Federal Specifications Board. The purpose of the Board is standardization, coordination and economy in the procurement of materials and services, other than personal, used by the Government, avoiding duplication in effort, and the better utilization of industries. I can illustrate the necessity for this by saying it was very often a matter of reluctance for a manufacturer to bid on a Government contract. It was oftentimes only a sense of patriotic duty that would induce him to bid. That situation has been very much cleared up. The duty of the Board is to adopt standard specifications for materials and services, such specifications to be in harmony with the best commercial practice wherever conditions permit, bearing in mind the desirability of broadening the field of supply for present economy and future emergency. Efficient and economical purchase presupposes standardization and definite specifications.

The Federal Specifications Board is composed of one member from each department and establishment that purchases materials and supplies in accordance with specifications. The initial meeting of the Board was held on October 31, 1921, at which time an executive committee, consisting of representatives from the ten Executive Departments, the Panama Canal and the General Supply Committee, was formed, as being more compact for the routine business of the board. The committee meets once a month, about half an hour in the morning. The Director of the National Bureau of Standards is ex-officio Chairman of the Federal Specifications Board. The detail work of the Board and its 76 technical committees is handled by the Vice-Chairman.

The procedure adopted for the consideration of specifications is as follows: The need of specifications for a given article or material, for either technical or business reasons, is fully considered by the executive committee and the subject is then referred to a technical committee, composed of the government experts in the particular subject, for consideration of all existing government and commercial specifications. On each technical committee, any department or establishment that wishes to be represented has representation. A specification which will be suitable for the uses of all departments and independent establishments of the Government is selected or written by this committee. The cooperation and advice of interested commercial and industrial concerns is requested and their recommendations are fully considered. The specification, as agreed upon by the technical committee, is then submitted to all departments and establishments of the Government, through their respective representatives on the board, for their comment and criticism; at the same time copies of the proposed specification are submitted to the American Engineering Standards Committee with request for its informal assistance in securing comments and criticism from the various engineering and technical groups in the country. All criticisms are referred back to the technical committee for consideration. When the specification is finally agreed upon, it is promulgated by the Federal Board as the official United States Government Master Specification for use in connection with the purchase of material covered by it.

The Master Specifications promulgated by the Board cover technical details only. The individual specifications published by the several departments and independent establishments, and based upon the Master Specifications, include such additional non-technical information as may be desired, provided they do not amend or conflict with the technical details of the Master Specifications. The circular establishing the Federal Specifications Board provides that the specifications adopted and promulgated by the Board shall be binding upon all departments and independent establishments of the Federal Government, and acquires its authority from having been issued by the Director of the Bureau of the Budget, by direction of the President. If a department has not abided by the specifications, the Comptroller will not pass the bill. The Secretary of the Department has the right, at the time the specification is proposed but not later, to except his department from the operation of the specification but there has been no instance of that kind. The Federal Specifications Board thus has one great advantage over all other standardizing commissions in that the standard specifications, officially promulgated, are required by executive authority to be used by all departments and establishments of the Federal Government.

At present, the Federal Specifications Board is directing its attention to commercial commodities and is not considering materials and devices of a strictly military nature, such as ordnance material, ammunition and explosives, military aeonautics and chemical warfare supplies, general military equipment, materials used in connection with the construction of naval vessels, etc. The selection by the consumer of specifications or standards for such commodities, without due regard to the manufacturing problems involved, would be as serious as the establishment of them by the manufacturers without a careful consideration of the needs of the consumer. In the selection of specifications for Government use, the Federal Specifications Board is coördinating these two interests in a manner fair to, and understood by, both manufacturer and user. Eventually, all Government purchases will be based on correct standards of quality and practice; at least, that is our ideal.

Up to the present time, 476 specifications have been promulgated as United States Government Master Specifications, covering all of the more important commodities, and their use. by all of the departments, bureaus and activities of the Government, is mandatory by executive order. You can appreciate the advantage it is that the largest buyer in the country, which I think the U. S. Government is (the purchase of commodities by the Government runs from $250,000,000 to $350,000,000 a year) though of course in peace times the government doesn't have any great effect on the market, is setting up specifications that are commercial, and are understood, and that can be readily manufactured.

There is one other outcome of this I might mention, which is being carried out at the Bureau of Standards, and that is the use of these specifications by others than the government. Of course, the Federal Board is concerned only with the Government itself. Nevertheless, the states, several of them, many of the cities and other public purchasing bodies and also, to a certain extent, representatives of industry are very much interested in these Federal Specifications for their own use. I may illustrate from the architectural profession. I have been approached several times by the representatives of that profession, the National Association, on the possibility of aiding the architect in his desire to abide by specification. He would like to have, for example, the manufacturer to certify that he is manufacturing to a national specification, whether it be of the Federal Specifications Board, A. S. T. M., or what not. We are trying to develop the sense of the community on that certification idea. It evidently has very great possibilities from the point of view of the small user as contrasted with the large consumer. The large consumer can check himself up but the small consumer is not always in a position to do so. We have some hopes, we have some evidence in fact, that a certification scheme has very great promise, at least in certain industrial fields if, at the present time, not in all.

[Editorial Note. In accordance with this "certification plan," the Bureau of Standards has compiled lists of manufacturers who have expressed their desire to supply material complying with certain selected nationally recognized specifications and willing to certify to the purchaser, upon request, that the material thus supplied is guaranteed to meet the requirements and tests of the specifications. This plan has already been applied to 48 United States Government master specifications. Copies of any of the 48 lists of manufacturers, to which additions are being made from time to time, can be obtained upon request to **Engineers and Engineering.**]

Benefits of Standardization*

By PROF. W. C. WETHERILL

Director of Metals Utilization, United States Department of Commerce, Washington, D. C.

THE subject matter which naturally groups itself under the heading "Benefits of Standardization" presents a very large mass of material. It would be almost as easy to discuss the benefits of civilization itself because civilization rests to a certain measure on Standardization.

Standardization and Simplification have been the sole interest of the National Committee on Metals Utilization in the Department of Commerce, and while it is true that Simplification is not Standardization, yet the two terms are closely parallel. For the purposes of this discussion, therefore, stress will be laid on the benefits of Simplification, as these benefits are a duplicate of the benefits of Standardization.

The term, Simplified Practice, has been applied to the work being done in Washington in Simplification. It means the reduction of variety in sizes, dimensions, and immaterial differences of everyday commodities, as a means of eliminating waste, decreasing costs, and increasing profits and values in production, distribution and consumption. That, of course, is a very much simpler process than the deep technical considerations back of Standardization. Since the establishment of the Division of Simplified Practice in Washington as a functioning group in the Department of Commerce, there have been something over sixty commodities simplified.

Some Examples

Rough and smooth face brick existed before simplification in 75 different sizes and shapes. This does not include differences in the materials from which the bricks are made. It is merely the variety existing in their over-all dimensions. Since simplification there exist but two varieties. Previous to simplification common brick existed in 44 sizes and now there is but one.

Before simplification, hospital beds existed in 33 lengths, 34 widths and 44 heights. If you multiply 33 by 34 and 44, you find the possible combinations in this list to be 49,368 possible varieties of hospital beds. They now have one standard length, standard width and one standard and two special heights. The possible varieties in the new list is three.

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*Paper read before the Engineers Club, March 15, 1927.

Mr. Githens* spoke of grinding wheels. In a two-hour conference in Washington last year, there were eliminated from the list of stock sizes 459,400 varieties, leaving a diversification still in existence of 255,000.

Results

Some of the results achieved through the adoption of these measures are to be found in the following statistics: A chain drug store company, operating all over the country, simplified from 22,000 items down to 10,000 items, constantly carried in stock. Typical reductions were, talcum powder, 50 to 20 varieties, and soap, 75 to 25 varieties. As a result there was an increase in general turnover of 70%, in volume of business 43%, and in wage rates to employees 100%, a decrease in investment of 14%, in inventory time 67%, in inventory cost 56%, and in personnel of 58%. The payroll cost dropped from 20 to 11 percent of the sales; the rent descreased from 14% to 7% of sales; the number of warehouses decreased from 9 to 2; the number of depot employes, from 270 to 189; the cost of night work, from $5,000 a year to zero; and the loss on unsold merchandise from $263,0000 to $100,000 a year.

The Edward H. Riddle Company, manufacturers of electrical fittings, simplified their line from 4,000 to 40 items. They reduced the price of their leading item, as a result of this simplification, from $27.50 to $13.50.

The Knox Hat Company reports: "Before we applied simplification to the Knox Hat business, our annual business was $1,600,000 on a raw material inventory of $500,000, a turnover of 3.2. Now it is $4,000,000 on a raw material inventory of $176,000, a turnover of 22.7. Our inventory time was 4 days, and now it is a day and a half. That is a decrease in inventory time of 62½ per cent, in raw material inventory of 64.8 percent, an increase in turnover of 600 percent, and in annual business of 150 percent."

There are a number of similar cases that could be cited which reflect as great benefits would space permit.

To Sum Up

A summary of the benefits that result from Simplification is as follows: The manufacturer has less capital tied up in mechanical equipment, especially in raw materials, semi-finished stock and finished stock, storage space and repair parts; he has more economical manufacture, through less idle equipment, better scheduling of work, accurate cost accounting, long runs on large units, simplified packing, simplified material inventories, and reduced cost per unit; he has more efficient labor through smaller seasonal employment fluctuations, increased individual output, greater skill of workmen, ease of training employes, simpler and better inspection, small labor turnover, and greater earning power. The distributor has increased turnover due to concentration of stock, staple lines easy to buy and quick to sell, no slow moving numbers, more effective sales force and more concentrated sales effort. He, also, has a decreased capital requirement, because of fewer complete lines to carry, for maintenance stocks, for packing materials, for storage space, and for interest and other charges, and also needs a smaller operating margin. He obtains a lower overhead, less stock depreciation, smaller clerical forces, less obsolescence, quick and reliable delivery, fewer misunderstandings and errors, and, through the consequent lower handling charges, gives better service. Finally the consumer, the poor old consumer, who always pays the bill, his share is better value for his money, prompt deliveries, better quality, quick replacement service, lower maintenance cost, simplified specifications, and protection against unscrupulous traders.

Dollars and Cents

Statistical information is available which goes to prove that the investment which the industrial groups have had to make to accomplish Simplification has been entirely insignificant when compared with the results achieved. There is no place where industry can spend money to better advantage than on Standardization and Simplification. The simplification of paving bricks, reducing 66 varieties to 4, has saved that industry $1,000,000 a year. The simplification of sheet steel, from 1819 different sizes to 261 sizes, has saved $2,400,000. Reducing reinforcing bars for concrete from 40 to 11 items has saved $4,500,000 annually. Lumber-yard sizes were simplified to 40% of the variety existing previous to simplification, which resulted in a saving, as reported by the lumber industry, of $250,000,000 per year. The expense involved in carrying out these simplifications has been infinitesimal.

What Observers Say

The Honorable Lord Stevenson, who was Vice Chairman of the Ministry of Munitions Advisory Committee for Great Britain during the war, has made this statement: "Had simplification been more general in manufacture in this country at the outbreak of the great war, the ammunition supply to the armies would not have presented the problem it did, and if simplification and standardization had not been adopted for thousands of parts and articles, we would have lost the war."

Mr. Albert W. Whitney of New York has written one of the most enlightening documents on Standardization thus far published. In this discussion Mr. Whitney states: "Not only has nature developed types which can be enumerated and classified, but she has standardized for each a multitude of organs and functions. Individuals of the same species resemble each other in the minutest detail of structure and function. If this were not so, organized life would be practically impossible. Everything would be an individual problem with no possibility of generalization. Institutions and customs would be impossible, for institutions and customs and laws depend upon an underlying sameness of reaction. There could be no medicine, for there would be no uniformity of physical organization. There could be no surgery because a surgeon would not know whether he was cutting into a heart or a liver. There could be no organized education because each mind would be an educational problem by itself. An underlying sameness is the basis for every civilization." He states further, "Standardization is thus the liberator that relegates the problems that have been already solved to their proper place, namely, to the field of routine, and leaves the creative faculties free for the problems that are still unsolved. Standardization from this point is thus an indispensable ally of the creative genius."

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*See ENGINEERS AND ENGINEERING for September, 1927, p. 225.

This substantiates the statement made in the opening paragraph that the subject of the benefits of Standardization is almost in the same category as the subject of the benefits of civilization itself.

The industrial and economic supremacy of the United States rests, to a large measure, on the ability to manufacture goods in great quantities on a small margin of profit under high labor costs, in competition with countries whose standard of living is far below that here and where labor costs are but a fraction of our own. If this industrial supremacy is to be maintained, the contributions which are to come from Standardization and Simplification and the Elimination of Industrial Waste are vital.

Wrought vs. Cast[*]

ANECDOTES without number might be written of the heartbreaks, delays and losses attributed to castings. Nevertheless, for many purposes castings still have advantages all their own. Some of their limitations are, however, especially objectionable in large machines which have to be individually designed. Is there any escape from the loss incident to spoiled or defective castings of elaborate design? At last Science and Engineering are beginning to say, "Yes! How?"

Modern markets offer a great variety of slabs, plates, bars and structural "shapes," products of steel mills by processes which assure metal of high dependability, and uniformity of mechanical and electrical qualities, easily machined or welded or cut by flame torches, stronger and tougher than castings of iron. Their surfaces are good enough for many purposes. Dimensions are very close to standards. Wastage of metal is much reduced, together with the net weights. Uncertainties are almost eliminated. By their use in construction of machines a large burden of anxiety is taken off the nerves of the manager.

The designer enters a new field of wider freedom wherein materials and technique more closely satisfy the principles underlying his work. He no longer has to use metal an inch thick and liable to breakage where a tough $\frac{1}{8}$-inch plate is much better. Construction may begin as soon as designs are developed. No waiting for castings! Economy, adaptability and other advantages in many features are realized. Storage for patterns and their loss by fire disappear.

Designers no longer are hampered by economic necessity to re-utilize old patterns. Time is saved; costs reduced. Some machines can be completely fabricated in less time than formerly was consumed in making patterns. Predictions of cost and delivery can be made with less uncertainty.

In the new technique, steel up to 8 inches thick is flame cut within $\frac{1}{32}$ inch of desired dimensions, with surfaces smooth enough to be painted or requiring but light cuts if they are to be machined. Flame-cut parts match satisfactorily for welding. Half-inch plates are cut at a rate of 15 inches a minute, and 2-inch plates at $7\frac{1}{2}$ inches. Welding is done by electric arcs on machines which make most of the operations automatic and more rapid than handwork.

Again Science and Engineering are leading Industry into new paths and bringing benefits to the people.

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[*] Abstract from Engineering Foundation Research Narrative No. 130. Based on information supplied by R. H. Rogers, Industrial Engineering Department General Electric Company, Schenectady, N. Y.

References for further reading: "The Foundry," May 1, 1923, page 858; "The Foundry Trade Journal," March 5 and 12, April 2, November 12, 1925; "Iron Trade Review," December 30, 1926; "General Electric Review," July, 1927.

The Rivet

By J. C. HANNA,

Chief Engineer, Hanna Engineering Works

ONE of the first steps in the comprehensive procedure leading to the change for improvement of a structure, or method of construction, is a thorough analysis of the existing method in order that all its virtues may be comprehended and weighed. If this is not done, important or even essential good qualities may be lost in the change. The qualities lost may outweigh the qualities gained, with the result that the change proves later to be the reverse of the overall improvement originally contemplated. A disregard for this basic principle of engineering procedure has embarrassed many an engineer.

Perhaps over-enthusiasm for change is largely due to a disregard of the axiom "Be doubly assured you fully understand a thing before you presume to change it." It is not always easy to gather at hand all the considerations involved. Some of our engineering practices are based upon precedents which are obscure. The thoughts of engineers who established processes in use today were frequently unrecorded. The only legacy they passed on to us is results. We are faced with the problem of reconstructing their thoughts through an analysis of their accomplishments.

This problem is with us always. It is a function of progress. Each new metal working tool; each new material of construction; each new element of knowledge passed on to us from the pure scientist, or from the laboratories of applied science, has its far-reaching effect upon the kaleidoscopic cross section of engineering. There is hardly a design, or metal working problem, today which presents the same picture pattern to us that it did to the engineer of a generation ago.

The advent of the fusion welding process is of far-reaching consequence. As a new method of joining metal parts it immediately finds many fundamentally sound and legitimate applications.

We are faced with the problem of determining what joints are best made by riveting and what best by welding. In an attempt to draw a line between the practical fields of application of these two joining methods we can and should follow the correct procedure as established by experience. Therefore, one of the first steps should be to thoroughly familiarize ourselves with the rivet and the riveted joints.

The bar from which a rivet is made is reduced by hot working from an ingot less than a foot thick. An ingot of ordinary size worked down to a bar suitable for a ¾-inch rivet will have become nearly 2/3 of a mile long, and will have been subjected to numerous hot workings and incidental heatings. The ingot, billet, or bar is never quenched but cooled slowly on a hot bed. Each of these heatings is an anneal.

The metallurgical effect of this heat treatment is to break up the coarse crystalline structure of the ingot into a fine grained regular structure. The mechanical hot working squeezes out all pipes, bleed cavities, and blow holes, and divides the slag, or oxide, inclusions into microscopic parts which are negligible. The repeated hot rolling has set the grain of the steel longitudinally so it best resists the shear and tension to which it is subjected in service.

The result is a steel of such definite characteristics that various agencies, particularly the American Society for Testing Materials, have found it practical to frame specifications covering both the physical and chemical qualities of rivets. The physical tests specified include bending cold through 180 degrees flat on itself without cracking on the outside of the bent portion. Also the same bend test after quenching in water from 1,200 degrees F. The head shall flatten while hot to 2½ shank diameters without cracking at edges.

Rivets will pass much more severe tests. The art of steel making and of rivet making has advanced since rivet specifications were framed, with the result that rivets are now made which would easily conform to more rigid specifications.

Rivets were originally driven by hand hammer. The boiler maker of generations ago was skillful in wielding a hammer in each hand. A swage was used for finishing the heads. The first yoke type riveters were steam actuated, the piston working direct on the die. Some steam riveters amplified the available pressure by inertia of heavy moving parts, and were similar in action to a steam hammer. The hydraulic riveter soon followed. The first portable riveters (1873) were hydraulic. The first riveting gun of which we have knowledge was patented in 1875 and was operated like a steam engine, with fluid actuated D valve. The hydro pneumatic riveter was invented in 1895. In 1877 the plain toggle mechanism, or Allen type riveter, air operated, was introduced. The first toggle lever, or Hanna Mechanism Riveter, was built in 1903—today there are 700 styles and sizes.

Portable pneumatic riveters which weigh as much as 30 tons and capable of driving 1⅝-inch rivets of boiler quality through five inch grip are in use for heavy steel plate joining, such as hydro electric penstocks and spiral shells. One portable riveter for gas holders of ten million cubic feet capacity drives 2¼ inch rivets *cold*.

The near future will bring improvements and refinements of riveting methods, as well as reduced costs. Standardization of design and constant increase in volume of large building steel, mean repetition work in the fabrication shops, which, in addition to the high cost of labor, warrants increased expenditures for shop equipment.

Single machines are now being built into which may be placed raw standard shapes, such as plates and angles, and which will produce a column completely prepared for riveting. A conservative estimate of the saving thus made is $10.00 per ton.

A multiple riveting unit is to be added to this machine, which will then produce columns completely fabricated ready for milling, splice plates, brackets, and field erection. A further reduction in the cost is thus assured, as three men will do the riveting now done by twelve. It is believed that this machine, which entails over $100,000.00 initial investment will pay for itself in one year. This savings does not include the riveting economy. It is also adaptable to girders and H section columns.

Further economies in the structural shops are now being effected by cold riveting, which is done with good results. In automotive construction 90% of the riveting is cold. The companies making the greatest use of welding in automotive construction are also the greatest users of rivets. Spot and seam welding have their places in body construction, but have not taken precedence over riveting.

The modern laboratory instruments for research in applied mechanics, such as the optical extensometer and telemeter, etc., were not available when tests were made which determined the design rules followed today in riveted joint structures. The staunch and unquestioned reliability of millions of joints made to these rules proves that if the tests were crude to present day standards the inaccuracies resulted in errors on the safe side. But HOW MUCH on the safe side? This suggests further research.

A recent investigation of the behavior and of the ultimate strength of riveted joints under load by Commander E. L. Gayhart (CC), U. S. N., performed at the Bureau of Standards, indicates that two rows of rivets on each side of the joint are weaker than four rows by a negligible quantity, if slip is no consideration, and that the outside row should have no fewer rivets than the inner row. This last is particularly true of two row joints (two rows on each side of the joint) since these rows assume at least 2/3 of the load at all loadings. In fact, if alternate rivets are to be omitted in two-row or duplex seams, it would seem that they should be omitted from the inner row rather than from the outer, as is now common. By this line of reasoning the maximum support may be had for the caulking seam at no expense of plate strength and with economical disposition of rivets.

It is interesting to note that riveted joints tested by the Bureau of Standards exceeded in test their theoretical efficiency. The joint efficiencies, excellent though they were, would probably have been better if the rivets had been machine driven, particularly in the case of high strength plates that showed relatively poor friction value. It is conceivable, in view of the foregoing, that certain joint designs which indicate a theoretical efficiency of 93.7% may have a higher actual efficiency.

The riveted joint is standardized. Research is being constantly pursued. Text books contain full details of every commonly used joint, and are revised with progress in the art.

We often hear the statement "The weld was as strong as the plates joined." Just what is meant by "as strong?" Strength of steel can be expressed in various ways. A complete expression of strength must include the data relating to a number of characteristics of strength. The characteristics of strength which are pertinent to a certain piece of steel depend upon the use to which it is to be put.

With this fact in mind various agencies, committees, and bureaus of control have set up standards or specifications which must be met or exceeded by steel in order that it may be acceptable for structures such as bridges, steel buildings, boilers, etc.

Briefly, these are:

Low limits for phosphorus.
Ultimate strength—55/65,000 lbs. per sq. inch.
Elastic limit—one-half of ultimate.
Elongation in 8"—1,400,000÷ultimate.
Elongation in 2"—22%.

Weld metal falls short of these specifications chiefly in ductility as a natural result of its coarse, crystalline structure. The plate metal adjoining a weld will probably fall short in the same manner because of grain growth.

Welded structural joints hold forth some temptations which are alluring. The path of the engineer has always been bordered by temptations which are beyond the limits of good judgment.

A definite set of hard and fast rules for acceptance or rejection of a weld has never been adopted. It is pointed out that such rules are not possible due to the variable conditions surrounding welds. How then can any agency charged with the safety of lives and property formulate any standard measure or procedure whereby it may function effectively where welding is involved? Experience has demonstrated the complications contingent upon discretionary latitude on the part of inspectors.

Failure of steel in fatigue may be said to be due to the fact that it falls slightly short of being perfectly homogeneous. We believe that a material which is perfectly homogeneous will be subject to change of shape (strain) in absolute proportion to the stress placed upon it at any unit stress below that which will result in a permanent change in shape, measurable or immeasurable. If this were true of steel it is believed that steel would not fail under an infinite number of applications of force of any intensity below the proportional limit. In this case proportional limit would be synonymous with endurance limit. That this is *not* true of steel is due to its lack of homogeneousness. The very structure of steel makes perfect homogeneousness impossible.

Some steels are more nearly homogeneous than others. The characteristics of structure which contribute to reduce homogeneousness naturally lower the endurance limit. These are—large crystalline structure or grain growth—irregular or variable structure—inclusions of impurities—minute cracks—in fact anything which contributes to irregular stress distribution.

It has also been determined that surface finish bears an important relation to endurance limit. A rusted or oxided surface will reduce the endurance limit of a test sample as much as 40%. A sharply irregular contour or shape will greatly reduce the endurance limit of a test piece.

There is emphasis in the foregoing on ductility as well as endurance limit. The significance of these test data is explained with great clarity in the following excerpt from an Investigation of the Fatigue of Metals—Series 1922—by Professors Moore and Jasper, University of Illinois:

"The lack of correlation between the endurance limit and some other physical property of a metal does not signify that the latter is of no value as an index of the qualities of the metal. For example, there seems to be no correlation between the endurance limit of a metal and its ductility, yet the ductility of a material must be considered by the user. This lack of correlation simply indicates that, under repetitions of a definite stress, ductility does not markedly affect the strength of a material and that if there were any certainty that a machine part would never be subjected to extraordinary stresses the ductility of the material would not need to be taken into account. This is the case for springs provided with stops to guard against excessive deflection; and oil quenched high carbon steel, a material low in ductility, is frequently used for those springs. Notwithstanding, for most machine parts there is a probability that occasionally they will be subjected to rather severe overstress. The parts of the running gear of a motor car furnish an excellent illustration of this point. For the material in such parts ductility is important in furnishing insurance against a disastrous shattering failure under overstress. If a material is ductile, some hundreds of overstresses can be endured with no worse result than a slight distortion of the member. Moreover, it may be possible by means of straightening, heat treating, and polishing of parts, to repair this rather severe damage. This illustration has been given at some length, because there is a tendency for engineers to use one test and one test only, for judging a material and to feel that the adoption of one test implies the discarding of others. With our present knowledge, no single test can give an index of the usefulness of a material for all classes of service. The materials engineer should beware of regarding any single property of a metal — elastic limit, tensile strength, endurance limit, hardness, ductility, notched-bar value, etc.—as a complete indication of the usefulness of a steel. Static strength, resistance to impact, ductility under overstress, and resistance to repeated working loads are all important.

"It has been noted before that there seems to be no correlation between the results of fatigue tests and those of impact tests—either single blow or repeated impact tests. It should be carefully marked that such a result does not imply the uselessness of either the repeated stress test or of the single blow impact test; it does signify that the qualities indicated by the tests are not the same. Nothing can relieve the materials—engineer of the necessity of deciding which tests will show the qualities in metal demanded by the particular service to which a machine part or structural member will be subjected."

Investigation made by Dr. D. J. McAdam, Jr., at the United States Naval Engineering Experiment Station, Annapolis, indicates that steel from which rivets and structural shapes are generally rolled is less subject to corrosion fatigue, if heat treated in a simple and inexpensive way.

Corrosion fatigue is failure under repeated stress of a corroded sample. The corrosion endurance limit is lower when corrosion takes place simultaneously with repeated stress rather than when all corrosion precedes the application of stress. However, the latter endurance limit is lower than when corrosion is no factor.

With these facts established, fatigue tests on welds should be made on samples having an oxidized surface at the critical section, as a finished weld oxidizes; if this be impractical a modifying percentum factor should be applied to the endurance limit as determined by ordinary test.

Interesting test data on the endurance limit of weld materials are contained in an article under the title "The Fusion-Joining of Metalic Material in Aircraft Construction," by Mr. Samuel Daniels, appearing in the mid-November, 1926, issue of Mechanical Engineering, which reads, in part, as follows:

"The ductility and the impact resistance are not so high in a casting as in wrought material. Therefore a welded joint which is no stronger than the fused portion is not so strong as the original, unwelded stock when subjected to bending stresses and to shock. A cast steel, however, has nearly the same strength as an annealed wrought steel of the same composition and, consequently, in simple tension loading, the welded joint has an efficiency of 100 per cent. The efficiency is less if the wrought material is originally in the cold-worked or in the quenched and drawn rather than in the annealed condition.

"The influence of welding is felt in several other ways. The resistance of a welded joint to bending stresses, applied either statically or in a number of cycles, is less than that of the unwelded material. With 1025 tubing the endurance limit (on a rotating beam machine) of gas or arc welded joints is about 14,000 pounds per square inch, some 23 per cent of the ultimate strength of the joint itself. The strength of the joint is close to that of the unwelded tubing and the elongation in 2 inch for both was found, in one investigation, to be approximately 12 per cent (for torch welding). A butt welded joint in this mild carbon steel will fail when given a transverse bend of about 90 degrees, whereas the unwelded sheet will bend 180 degrees."

Mr. Daniels is Chief of the Metals Branch, Materials Section, Engineering Division, Air Service.

The endurance limit of rivet and plate materials is from 25,000 to 29,000 per square inch.

It is easy to draw an analogy between sharp irregularity of contour or shape, and the cross section of a welded joint wherein the plates have been notched or beveled and a dissimilar metal inserted in the notch.

It is only natural, in view of the foregoing, that the structural engineer is making a mental reservation regarding fusion welding as a method of joining until reports are available of weld metal and welded samples under repeated stress tests.

By welded samples is meant a typical rotating beam fatigue testing sample which is made with a notch weld at the center or critical zone.

The similarity of weld steel to an ingot before soaking or a steel casting before annealing is often cited, in view of which the following "high lights" of the steel casting industry are pertinent:

Thirty years ago approximately 90% of the steel castings poured were annealed, which proportion still exists, regardless of size and weight, both of which in some cases are enormous.

The difficulties encountered by the steel casting industry in the early days were chiefly due to lack of knowledge of the chemistry of steel, as well as the action of steel and gases under high temperatures and subsequent cooling, resulting in blows, shrinks, strains, impurities and weak structures. The high grade and uniformly reliable product of the present day is the result of accumulated and extended knowledge, backed by years of experience. One of the principal results of this knowledge is melting control, which has risen to scientific exactness. In welding no comparable control of melt can be made.

Annealing breaks up coarse, crystalline casting structures, and resultant planes of weakness, into fine crystalline structures, and relieves internal stresses, which, in some cases, are sufficient to cause failure before annealing.

Annealing evidences itself in pull tests by more than doubling the elongation and reduction of area, as compared with pull tests on unannealed samples, and in slightly reducing the elastic limit. All steel foundries, acting on their own volition, will anneal 100% of castings. Unannealed steel castings are used in compression only and it is interesting to note that footings, pedestals, and so forth, for bridges, are annealed steel castings.

The ductility of weld metal is similar to that of unannealed steel castings. The average ductility of samples of weld metal listed in Mr. S. W. Miller's article appearing in February, 1927, issue of Mechanical Engineering is 10.9% elongation and 22.37% reduction of area. The samples (seven in number) were taken from very large welds made automatically and, therefore, may be presumed to have had the beneficial effects of the annealing supposed to result from layer welding. This welding was done under the most ideal circumstances known to the welding art today.

Can annealing, either by welding in layers, or by general application of heat, be effective in the correction of the adverse results of intense heating? The metallurgist of a steel foundry would answer "Probably not, because we know a casting from a burned or oxidized batch of steel in the furnace cannot be entirely cured by any heat treatment." (The temperature the weld metal passes through exceeds that of an open hearth.)

If an attempt were made to relieve shrinkage or heat strains by local application of heat after welding, the result is only to move the internal stresses from one location to another.

Much has been said by welding proponents on the subject of continuous construction of beams made possible by weld joining.

Bear in mind that such construction is possible with riveted joints, even at columns—this has long been recognized, and many printed discussions are available on the subject. As recently as last November, Prof. C. R. Young presented a paper which appeared in the Canadian Engineer which discusses, among other things, the fixture or partial fixity which exists at the adjoining ends of riveted beams.

Also bear in mnid the whole theory of continuity is dependent upon the assumption that columns will forever have exactly the same relative height they had when beams and girders were joined. If one column should settle slightly the positive and negative moments would change materially. The continuous beam value would be reduced if not entirely lost, even though the joints remain unbroken. A continuous beam construction may be likened to a chain wherein the strength is equal to the weakest link.

Continuity of beams through one column depends for perfect fixity upon the reliability of at least six welds in the line of the top flange of the beams. It requires courage, therefore, to assume "perfect fixity." What theory are we to follow in calculating the modifying effect of heat stresses to continuous beam formulas?

Commenting on the possible adoption of welding of steel structure, Milo S. Ketchum, Dean of the College of Engineering of the University of Illinois, in a paper on "Research Investigations in Connection with the Structural Steel Industry," before the members of the American Institute of Steel Construction, said (quoting from the Iron Age, November 4, 1926):

"The allowable stresses, details of design, methods of erection and other phases of steel structures with riveted connections are controlled by specifications that are the result of experimentation and experience in the shop and field and in service. While the tests and experience with welded structures would appear to indicate that welding has an important place in the fabrication and erection of steel structures, much study, investigation, and experimentation will be necessary before welding can be generally adopted in place of riveting.

"From this discussion it would appear entirely probable that riveted connections will continue to be used for heavy frame work for bridges and buildings, and where difficult erection problems occur and for structures of complicated design where it is necessary to design for deflection stresses. It should be remembered that a riveted structure has sufficient flexibility to change its form to take the load, while the welded structure with its more rigid joints will lack this flexibility. It would appear, therefore, that the economic design of articulated welded structures will require that the stresses be calculated with greater accuracy and that the design be made with greater skill than is necessary in the design of riveted structures."

Changes in Alien Population

More than 45 per cent, or nearly half of our net gain in population through immigration since the 1924 restriction act went into effect, have been English speaking immigrants, according to an analysis of immigration made by the National Industrial Conference Board. This is a nearly four times greater proportion of English speaking immigration than before the war, when, for the fiscal years 1912-13-14, the English speaking proportion of alien net gain in population constituted less than 12 per cent of the total.

In actual numbers, fewer are coming from Great Britain and Ireland than before the war, the average number of arrivals for the years 1925-26-27 amounting to 52,154 as against an average of 81,549 during 1912-13-14. This loss in English speaking arrivals from Europe, however, is to a large extent offset by a considerable increase of immigration from Canada and Newfoundland, arrivals from these dominions, of whom about two-thirds are of English speaking races, averaging 93,567 a year during 1925-26-27 as against 71,977 during 1912-13-14.

More than five-sixths of our total alien population growth during the past three fiscal years, that is since the 1924 act went into effect, came from Great Britain, Ireland, Canada, Germany and Scandinavia. Mexico however, is rapidly taking the place of Italy as the source of our greatest foreign speaking immigration, our net gain in population from that country, the influx from which is subject to no quota restriction, constituting nearly one-fifth, or about 19 per cent of the annual average net gain by immigration since 1924. Italian immigrants during the last year before the war made up more than one-fifth, or about 23 per cent of the 1914 total net immigration.

The huge influx of Italian people noted before the war has, in effect, been turned into an exodus under the quota restriction. While a total of 32,846 Italian immigrants have entered since 1924, 65,092 Italian aliens have left the United States since then, leaving a net loss of 32,246 for the three years, as against a net gain in Italian speaking population of 447,465 during the last three years before the war. The comparatively large exodus of Italian people from the United States, however, is merely the aftermath of the huge Italian immigration before the war, all migration necessarily being followed by a certain percentage of returns and re-entries. With a quota of less than 4,000 as against an annual pre-war immigration exceeding 200,000, it is but natural that returns still far outnumber arrivals.

German immigration to the United States has increased considerably since the war and, even since the 1924 restriction act went into effect, has averaged 50 per cent more than during the three pre-war years, the annual average of German immigrants during 1925-26-27 being 48,334 as against 32,617 during 1912-13-14. Scandinavian immigration under the 1924 quota act averages less than two-thirds of what it was in the pre-war years, amounting to 19,235 during the fiscal year 1926-27.

Mexican immigration has nearly trebled, the average influx for the three pre-war years being 15,348, as against 47,261 since the 1924 act became effective. Mexican immigration during the last fiscal year amounted to 66,766 and comparatively few, less than 5 per cent on the average, return or otherwise leave the country.

Aliens of the following nationalities or races during the past fiscal year left the country in greater number than those of their respective nationality or race who entered: Bulgarians, Greek, Chinese, Japanese, Portuguese, Rumanians, Turks, and West Indians. Owing to the great increase of Italian immigration during the past year, made possible through the law permitting the families of nationalized citizens and Italian war veterans and their families to enter as non-quota immigrants, Italian entries for the first time since the quota act became law outnumbered departures, though by less than 700.

Analysis of Causes and Methods for Prevention of Highway Accidents

By **CHARLES M. UPHAM,**

Director, American Road Builders' Association

EVERY forty-one seconds someone is either killed or injured in highway accidents in the United States. During the five years ending with 1927 the staggering total of approximately 3,446,370 persons were reported injured and 114,879 killed in traffic calamities, most of which were avoidable. The annual casualty toll of highway accidents is more than twice as great as the entire number suffered by the nation's forces in the World War. The figures in detail are as follows:

Accident Tolls

Year	Killed	Injured	Economic Loss
1922.........	19,203	276,090	$484,875,750
1923.........	22,621	678,630	571,180,250
1924.........	23,291	698,730	588,097,750
1925.........	24,462	733,860	617,665,500
1926.........	25,302	759,060	638,875,500
5-Year Toll...	114,879	3,446,370	$2,900,694,750

The combined efforts of several national safety organizations, among them the Hoover Conference on Street and Highway Safety, the American Road Builders' Association and the National Safety Council, and several years of scientific research into the causes and results of highway accidents have brought to light the many hazards that result in calamity to motor vehicles and to pedestrians. Foremost among the causes is carelessness. Foremost among results is the five-year loss of nearly 3,500,000 injured, 114,000 killed and an economic loss approaching three billion dollars. The result of their findings has been a decrease in the number of casualties per motor vehicle registered in the nation, although the total number of deaths is increasing at the rate of nearly 2,000 annually.

Statistical Research

Statistical research has uncovered many peculiar facts in regard to the causes and results of highway accidents. The knowledge of these facts has given national organizations interested in the public safety movement a basis upon which to work and is expected to bring a noticeable reduction in the accident casualties within a few years. Paramount among the conclusions that have been drawn from statistics collected from various rural districts and municipalities are:

1. That the largest number of accidents occur between five and six in the afternoon when business men and workers are returning hurriedly to their homes. At this period of the day, congestion on the street and highway is at its height. The psychological phase also enters into the fact that accidents are numerous at this hour. Drivers and pedestrians who are wearied from a day of labor are not as mentally alert as during the earlier hours of the day and, as a rule, are in a hurry to reach their homes. Confusion and carelessness result, and from them—accidents. See Fig. 1.

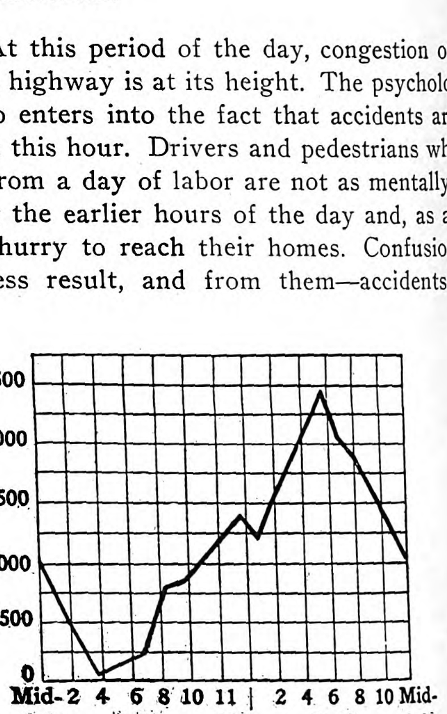

FIG. 1

2. That the accidents involving pedestrians are increasing at a rate much greater than the rate of increase of other types of accidents. An example of this was found in Massachusetts, where the registration of automobiles has increased 160 per cent during the past six years. In that state the collisions between automobiles have actually decreased, while the calamities involving pedestrians have nearly doubled since 1921. The pedestrian evil seems to indicate that the American motorist is becoming adept in the art of dodging other vehicles, but is unable to cope with the problem of the pedal traffic on city streets.

3. Less than 5 per cent of all accidents are the result of faulty mechanism of vehicles or improperly designed roads and streets. The human machine is responsible for the remaining 95 per cent of the accident total. Carelessness and incompetency have been found to be the chief illnesses of the human machine resulting in disaster.

4. The annual death of 7,000 children of school age has caused an intensive research into the causes of these youthful mortalities. It has been found that more than twice as many children between the ages of 6 and 12 are killed as between any other similar group of years between 1 month and 70. Children at the age of 6 are just starting their daily journeys to and from the schoolroom and, for the first time, are their

own masters on the street. They have no fully developed ability to judge speed and distance and, as a result, are the victims of the accident evil. The reasons for fatalities between the ages of 6 and 12 are, for the most part, psychological and avoidable through proper education of the child. See Fig. 2.

5. While the total number of accidents resulting from recklessness by intoxicated drivers is small as compared with total accidents reported, they more often result in mortalities. Drastic legislation in nearly every state has brought the number of deaths from this source to a considerably lower level than in 1921. In New York State intoxicated drivers were responsible for 458 personal injuries in 1925, and the licenses of more than 1,600 intoxicated drivers were revoked during the same period.

6. The economic loss resulting from highway accidents is estimated at $50,000,000 per month, or $600,000,000 per year. This conclusion has been drawn from reports of various insurance companies and police departments of the country.

Psychological Research

A great mass of data has been collected by organizations investigating the psychological phase of highway accidents. The outstanding single mental condition giving rise to casualties is fatigue, which, in turn, causes carelessness, recklessness and a general decline in the ability of a driver or pedestrian to act speedily and accurately. In the child problem, general inattentiveness has been found the chief cause of fatalities and injuries. The child at play is a bundle of trembling nerves and, in the joy of the game, is almost unconscious of any world but its own. He may run into the street and, being there, continue his pleasant pastime without regard to the motorist. Every driver has some knowledge of the irresponsibility of the child at play. Such knowledge excites the driver and dangerous confusion results. The same condition prevails with child pedestrians, who have contributed an amazing portion of the highway mortality.

Mental and physical defects of drivers have caused a large number of accidents, although general carelessness is far more important.

Thoughtlessness and poor judgment are the cause of more than 40 per cent of all accidents. These classifications include jay-walking, inattention, confusion, inexperience and recklessness. This classification, however, overlaps the group of accidents attributed to carelessness, and should not be reported as distinct causes in themselves.

The American Road Builders' Association is now launching a campaign to cut down the toll of the street and highway. The organization has conducted an exhaustive investigation into accident causes and results, and its conclusions, in fine, are that the individual alone holds the key to the solution of the accident problem.

Ultimate Objectives

The ultimate objectives of the general movement for highway safety are as follows:

First, the education and regulation of pedestrian traffic as well as motor vehicle traffic. Pedestrians and motorists are to be considerate of each other and share the necessary delay caused by courteous and cautious conduct. Along rural highways, where there are sidewalks, pedestrians will be expected to use them. Where sidewalks are unavailable, pedestrians will be expected to use the extreme left side of the road facing the traffic flow. In cities, pedestrians are to be instructed, urged and even required to keep within the boundaries of designated safety zones and crossing places and, where there is congestion, to cross only with the traffic. Pedestrians as well as drivers are to be subject to the traffic regulations, the violation of which would be considered a misdemeanor.

Second, the adoption of a standard code of motor vehicle laws in every state of the union. This is expected to reduce accidents resulting from ignorance of regulation and custom. A code has been drawn up by the Hoover Conference as a model for state adoption. The code should include a thorough examination of all drivers.

Third, education in safety and accident prevention, as the American Road Builders' Association recommends, will be incorporated in the curricula of elementary schools. More advanced training in safety and traffic matters will be developed in schools for teachers. General education of the public will be undertaken through newspaper and magazine publicity, etc. A pledge card binding the signer to the use of courtesy and caution will also be issued by the Association to all drivers and pedestrians willing to cooperate in the movement. These cards are obtainable from the American Road Builders' Association, Washington, D. C.

Fourth, motorists will be asked to protect the design and materials of their automobiles by periodic adjustment and replacement. Particular emphasis will be put on the construction and adjustment of headlights, steering apparatus and brake mechanism.

Fifth, a comprehensive program of street widening and the elimination of grade crossings will be carried out throughout the nation. Grade crossing accidents account for approximately 9 per cent of the total highway traffic deaths. The railroad hazard is rapidly decreasing, however, as the result of installation of signals and gates, reduction in the number of crossings and safety legislation.

Mass-Transportation in Cities

By J. ROWLAND BIBBINS

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"TRAFFIC," as generally discussed, is simply another name for "mass transportation," though rarely so understood. It is worth while to broaden our conception for the moment to include base principles, trends and future needs, to see whether the real problem will ever be met by any other policy of approach than sound technical planning, based upon transportation experience.

The traffic problem of today seems to be the result of bad planning of yesterday and lack of appreciation today of transportation essentials.

The Perspective

The average large city per million people covers	100 sq. mi.
The Metropolitan District—	
Average mileage of paved streets	1,000 mi.
Average mileage of street railways	500 mi.
Average motor registration	100,000
Large city population doubles in 5 to 40 years	Average 30 years
City land values increase	About three times
City passenger traffic, rail and motor	About four times
Railroad freight tonnage	About seven times
Railroad passenger traffic	About eight times
Motor registration, U. S.	Last doubled in 4½ years, decreasing rate of increase.

Therefore, study now the problem of doubled population without stopping to quarrel just when it will take place. The above perspective of the physical problem today, and the clear trends of traffic growth tomorrow are sufficient, for the purpose of this discussion, to put to the acid test the propriety of any opportunist policy, i. e., to decide whether superficial or fundamental measures are in the best interests of the community as a whole; whether, in our mad scramble for relief, the right emphasis is being placed upon the various elements of the problem today in due proportion to their real importance; and whether we have thoroughly appreciated and understood the dynamics and economics of mass-transportation, both passenger and freight. Transportation is a highly technical business with ten or a dozen entirely different specialized types of carriers, all competing for the use of the public streets, either for actual operation, or for search of patrons.

My perspective of any traffic and transportation problem involves all these elements: rail, transit, bus, truck, taxi-cab, automobile, horse, pedestrian, and even water transport—all to be co-ordinated in a city-wide, well integrated, unified, transport system, for both passengers and freight, with "track and service" capacity adjusted to local needs, and particularly to recognize the differentials in speed and bulk of these various transport agencies.

At the outset, I submit the debatable proposition that **the private automobile is not by any means the greatest part of our problem**; and freight transport, which has been almost entirely neglected, looms very large in the picture, especially in the central district.

Passenger Transport

Time is the first essential between home and work. The 30 minutes' time zone practically defines the boundary of our denser city areas. Five minutes saved expands the zone one mile; 15 minutes, three miles. Thus, four times the populated area can be brought within the 30-minute time zone at the same cost. Here is the final answer to traffic congestion and motor competition, but it involves an understanding of the "Speed-Time Curve," i. e., acceleration, deceleration, loading and unloading, signalling, etc., and the proper design of track, equipment and power, all of which are the Ten Commandments of the transportation engineer.

It needs no demonstration that the widespread use of private motor in rush-hour transportation is due largely to the demand for speed, increasing with the spread of our cities which are distinctly trending toward reducing the average density of population, as the American standard of home life rises. Troublesome as it is, **the private motor is fulfilling an economic need, complementary to established public agencies which may not fill that need.**

An ideal transport system is based essentially upon speed (and fare) differentials:

(1st) railroad suburban service, steam or electric to central terminals or through-routed;

(2nd) rapid transit on private rights-of-way, surface outside, and elevated depressed or subway inside;

(3rd) automobiles and taxicabs;

(4th) buses, express and local;

(5th) "shanksmare."

And the last is by no means unimportant, for our surveys show that over 25% of our industrial employment walk to work. Industries are being relocated to make this possible.

Now, in practice, we are trying to run both "express, local and freight" services on surface streets already cluttered by business. A modern transit system handles 20% of the total traffic in the maximum rush hour, and at least the entire population once every day. Rapid transit system peak loads run from four to ten times mid-day movement. In large cities, rush-hour "tripper cars" can make only one load-trip during each rush period. While central "loop traffic" will always be heaviest, cities are developing more and more through-riding and cross-town riding, entirely outside of the loop.

Transit routing and terminals are thus of fundamental importance, though many systems still adhere, mainly by necessity, to the "town pump" system of focusing all service and transfer facilities at the center, which involves the serious question of franchises. For example, in one large city I found private automobiles handling as many rush-hour passengers as street cars, and the in-bound evening traffic peak at the Loop, equal to that of the morning, which clearly indicates the public demand for through-transit across the city. This transit system was all radials with a mass of downtown interlocking loops and pay transfers. Chicago, on the contrary, has so decentralized its passenger transport by outside cross-town lines that, with over 3,000,000 people and 300 sq. miles in area, surface lines still handle the major portion, despite the elevated system, express and local.

After years of study of transit and traffic and the practical aspects of city planning, zoning and motor transport, I submit the proposition that the electric car, mainly surface transit, is still the essential backbone of passenger mass transportation, which neither the bus, taxicab, jitney, or private car can displace, at least until our cities can finance adequate replanning. Simply the volume of movement is too great for small units. Each form of motor transport, however, has its particular part to play in a properly unified system of differential speeds, fares and services. In view of the existing paving situation, mounting taxation and straitened financial condition of our cities, it seems idle to talk now of replacing the transit system by buses, except in very specific instances and localities.

By the same token, it is the clear responsibility of the electric railway industry and city officials to develop transit of every class to maximum schedule speed and capacity. The motor must play its part, largely complementary, rather than competitive. No adequate City Traffic Plan will survive the acid test of experience and public need, unless it recognizes all transport elements in true perspective. We shall not by fiat clear our streets of 14,000,000 city motors, nor shall we relegate to the scrap heap 30,000 miles or more of urban railways.

Freight Transport

The volume of motor freight is exceedingly difficult to estimate, although we know that all of our package freight, or less than carload lots, requires one or more terminal handlings in our cities. Not many years ago, over 50% of the l. c. l. freight interchange between roads in the Chicago Terminal District was transferred by horse truck cross the city streets, mostly downtown.

Little progress has yet been made in night haulage of commodities and construction materials; little in consolidated motor trucking, to increase the loading efficiency of the city truck; and little or none in the scheduling of merchant deliveries during off-peak hours for consolidated motor delivery, to reduce waste mileage and avoid peak congestion. Moreover, Store-door Delivery is being agitated. Many city industries are delivering to terminal by truck, rather than incur the delay of terminal interchange, and the Pennsylvania Railroad has abandoned its way-freights, within an 80-mile radius of Philadelphia, in favor of motor truck. Cincinnati interchanges freight between roads by motor. Clearly, the tendency of local freight transport is more and more toward the public streets, a result found in the traffic analysis of any large city. An accident map, recently shown in Philadelphia, showed more serious and fatal accidents, downtown, due to trucks than to automobiles. And I have found in some downtown cordon traffic counts, that truck and delivery movement in a large city is perhaps 50% of the automobile movement, in many districts exceeding that of automobiles.

Thus, bearing in mind relative speed, bulk, and character of vehicles, it is perhaps not an exaggeration to say that motor freight transport has grown to be as serious a part of the traffic congestion problem as the private auto. Yet, it has received very little, if any, detailed study and consideration. I submit it as being deserving of equal consideration in the City Traffic Plan, not so much for its volume as for its obstructive nature.

Express and Local Service

Coming now to specific recommendations, the only way to insure needed speed is by traffic segregation in the Thoroughfare Plan, with different streets made available for transit (which usually needs business streets), for fast traffic (usually automobiles and bus), and for slow heavy-duty trucking, respectively. A detailed examination of most city street systems will reveal possibilities for securing this segregation.

Some City Plans call for "Heavy Traffic Streets" which should mean for volume of fast traffic, rather than mean for slow cumbersome freight traffic. From transit trunks lined with business, speed traffic should be diverted so far as possible to other through speedways or express streets, even though not as wide, unless safety loading stations are well marked upon the pavement and protected by mushrooms to indicate reserved space. These are also useful as pedestrian safety stations. The policy of concentrating all traffic on dense transit streets simply defeats all fast transportation, both rail and rubber. It also eventually forces the erection of loading platforms with "lighthouse" bumpers for protection. Such fixed obstructions in the roadway, loading stations, signal towers, blinkers, bobbies, etc., should never be encouraged. Full street capacity ought to be demanded for movement and all dams, which slow down and pile up traffic otherwise able to clear itself automatically, should be removed. Street safety zones are as far as we should go in this respect. These offer the least obstruction and, when not occupied, may become part of the open thoroughfare, as in Detroit. I see no justification in removing from use 27 to 30 feet of a valuable roadway 24 hours per day to accommodate infrequent car schedules. Downtown it is another matter; the headway or density should control.

To obtain speed with existing conditions, we must have limited-stop service for "expresses," meaning "skip-stops." The bus, although less mechanically suited to frequent stops, will probably have to perform this service and, stopping at the curbs, may raise the transit schedule speed to 15 m.p.h., outside of the central zone. It appears from experience that large-capacity buses, especially "double-deckers," cannot make the high schedule speed demanded, largely due to unavoidably slow loading and unloading. The small-capacity unit really fulfills a good purpose on a transit trunk. The real reason 7-passenger jitneys have survived in Detroit is because they are needed. Making only 2 or 3 stops per mile, they are today able to double the street car speed and far exceed the local buses. Large capacity buses, of course, have their field, especially in developing new routes, but distinctly not on transit trunks.

Paving

Adequate continuous paving lies at the bottom of practical traffic segregation, needing no signs, signals or policemen. A relief route, well laid out and re-conditioned, will immediately be discovered and used. A wide distribution of simple little pocket route maps, one for fast traffic and the other for heavy-duty slow traffic, will accomplish more than a ton of ordinances. The paving program should, therefore, become an element of the City Traffic Plan. As there are approximately 1,000 miles of city pavements per 1,000,000 city people, here is perhaps the major economic problem of traffic and one which has been generally sidestepped.

This drain upon the city budget for both capital and maintenance is now becoming oppressive, and there is need to re-examine the cost of building and maintaining "track" for rail and rubber mass-transport in relation to the usefulness and destructiveness of each. Electric railways are spending over $12.00 a foot, or $65,000 a mile, for track structure alone, including solid concrete foundation under ties and pavement.

Any paving program must be financed on the basis of relative usage and wear. Thousands of miles of old light pavements have suddenly been thrown into heavy duty service for which they were never designed. Financing traffic street pavement at $50,000 or more per mile is a far larger problem than financing railway track at $65,000 per mile, exclusive of pavement. It will not do to wave the matter aside as one of general taxation, and the cost of motor "tracks" will have to be recognized as part of the cost of transportation by rubber. This economic necessity points the warning finger to the indispensable need of segregation in the City Traffic Plan and of properly designing streets to suit that segregation.

Terminals

Railroads cannot operate without terminals, but we are expecting this from city traffic, an impossibility. I regard day storage, as distinct from short-time parking, as one of our "essentials." This very practical problem has been utterly neglected. A few "deluxe" garages charging $0.75 to $1.00 per day will have no appreciable effect upon congestion. Nearly half of the road drivers use Fords, and a day storage service of not more than $0.25 will have to be developed if real results are to be expected. Garaging has thus become an important national industry, and the community itself may have to undertake some form of self-supporting garage service at cost. In any event, it should be distributed in small units, rather than concentrated in large ones, to prevent the ramp or elevator capacity, yielding the necessary speed and safety for rush-hour peak, running into prohibitive investments and rates. Rear lot areas, not high priced frontage, must be used for this purpose, though we may afford an arched front entrance.

The Parking Problem is too involved to discuss here adequately. I do not think it has, generally, been approached scientifically or fairly. Enforcement resembles, too closely, that of the 18th Amendment. Graded parking, designed according to local need, and efficient enforcement are, both, practicable and necessary. My survey indicates an average demand of less than 30 minutes. A recent comprehensive merchant store survey, in a "no-parking" city, shows nearly 20% actual auto patronage, and over 40% total via motor.

Wider Road Bed

Railroads usually had the foresight to provide a 100 ft. right-of-way against their future needs, and expanded by adding tracks.

Similarly, the old decimal system of street width must give way to one based on the number of lanes needed. The standard width should be adjusted further according as the streets are to handle street cars, buses or trucks, or motors only, for there is 3 ft. difference in the widths of these vehicles, or over 50% of the standard auto width. The volume of movement should help control; thus, a transit street operating 30 seconds rush-hour headway should be more liberally designed than one operating 10 minutes headway; similarly with buses and trucks.

But street widening is daily becoming financially more prohibitive. It has taken Chestnut Street, Philadelphia, fifty years to widen from 40 to 50 feet, and several old buildings still stick out into the sidewalk. The efficient method of "arcading" to widen roadways to double present capacity, while still preserving the old air rights, has made no progress because of building owners' opposition. Yet, wholesale arcading would probably cost not over 25% of full street widening. The Commercial Trust Building, Philadelphia, and the Vesey Street Telephone Building, New York, are good examples. Woodward Avenue, Detroit, scheduled for widening, has now reached frontage values of from $800 to $6,000 tax value per front foot, averaging over $2,000 market value. To widen 20 feet each side at this price would cost over $4,000,000 a mile, without damages or pavement.

The alternative is double-decking, even more financially burdensome. The South Water Street double-deck improvement along the Chicago River, known as Wacker Way, cost $30,000,000 a mile, as did the London widening, Kings Highway to the Strand, but, in Chicago, the benefit assessment practically absorbed the damages awarded. It is clear that few cities can undertake such an ambitious program over large areas, complicated, as it is, by the ramp and the problem of ventilating the lower level. This last has received little consideration, although we introduced it into the design of Wacker Way.

Operating Efficiency

For the present, our one hope for increasing street capacity is in efficiency. A railroad superintendent operating on two tracks of a 4 or 6-track system would promptly be fired. Yet we are doing just that thing in traffic. And my closing proposition is that, until we devise some equitable source of further public revenue for vast public improvements, higher efficiency in mass-transportation, rail and rubber, is our main avenue of escape. In one larger city, with 90 ft. streets and 60 ft. pavement, I found, within the mile square, only 25% traffic efficiency, assuming solid parking or perhaps 12% clear. This city was actually encouraging one-line traffic each way, and could easily have doubled its capacity. I think we must come to parallel lanes marked with white paving blocks or flat white metal plates. Now, the capacity of our streets is reduced at least 50% by "meandering" or straddling lanes; the big buses are notorious offenders in this respect.

The reversible center line on heavy traffic streets has been tried, at least in Cleveland, with success. The New York elevated delivered express service with 3 tracks, reversing the center track morning and evening, giving the equivalent of 4 tracks for express and local. By this simple means, present streets can be increased from 50 to 100% in rush-hour peak capacity, when capacity is most needed.

One-way streets are generally an economic blunder and, in any case, should be in pairs rather than single, though cutting the total street capacity in half. Reversible *street* operation, morning and evening, is clearly impracticable, but reversible *center line* is practicable. Of course, when a street is just too narrow for safe 4-line operation, then one-way movement may be justifiable, but the practice has spread throughout the country largely by one city copying another without due consideration, with very questionable results.

Grade-Crossing Control

We all grumble when the Capitol Limited or 20th Century is held up at some block signal, yet I venture the assertion that probably *50% of the total crossing time and capacity of our city traffic intersections is being wasted by badly adjusted "stop and run" signals or in hand control, by waiting for "stragglers."* Railroad signal practice pointed the way 30 years ago. The Chicago system of progressive interlocking movement and, especially, with independent control of each intersection, not only as to period but also as to time ratio or balance of traffic, is the one outstanding encouraging development. The cost of learning our lesson through experimentation has been tremendous; nevertheless we are learning.

The shortest possible signal interval is essential for maximum volumetric efficiency. This can be determined only by "calibrating" a traffic crossing under different load conditions. It is a general observation that the usual run of signal installations throughout the country have retarded traffic movement and diverted it from the logical artery to others less suitable. Example: one of our largest cities installed a stop-and-run system, 100 seconds cycle on its main business trunk carrying rush-hour car service at 22 seconds headway. Result, which any transportation man could foretell; from 2 to 3 minutes added trip-time to every car entering the business district. This is not efficient transportation or planning. It is not enough to hide behind the slogan "order and safety." We must have both safety and speed, but this will never be realized until mass-transportation, both rail and rubber, is designed and operated collectively along modern transportation lines and so conceived in the City Traffic Plan.

Record Disaster Relief Tasks Shouldered by Red Cross in Past Year

ANNUAL MEMBERSHIP DRIVE, NOVEMBER 11 TO 24, DESERVES UNIVERSAL SUPPORT

NEVER before in the history of the American Red Cross has it been called upon for disaster relief service of such magnitude as in the fiscal year which ended June 30, 1927.

In that period the Red Cross disaster relief service took the field in Florida, and with that task scarcely completed, found itself with an unprecedented flood threatening in the Mississippi River Valley in the early spring. Few realize that the flood did not suddenly roll up to its terrible size of early summer. As a matter of fact, the flood was menacing individual localities long before the general public suddenly awoke to its destructiveness. The Red Cross, however, did not wait for the later stage, but was working through its local representatives virtually from the start of the disaster.

Altogether during the fiscal year the Red Cross served in 75 disasters within the United States, and in 20 foreign countries. In neither of the two outstanding relief tasks of the year, the Florida storm and the Mississippi flood, was the Red Cross free to concentrate solely on the one disaster. Calamity in serious form struck 25 states during the period under discussion. While the Red Cross was endeavoring to cope with the wreckage and distress caused by the Florida storm, its relief forces were directing relief following a tornado in Ohio, a devastating fire in Alaska, and floods in Illinois, Kansas and Iowa. Later, as though the Mississippi's rampage was not enough to tax resources of even the Red Cross relief organization, backed as it was by every necessary branch of the Federal government, twelve other disasters simultaneously called for relief, which was extended with the same effectiveness with which the grim battle in the flooded Mississippi Valley was being waged.

Mississippi Relief

To emphasize what these multiple demands on its strength called for, some details from the Mississippi relief operations are significant. During this undertaking, the Red Cross fed and otherwise cared for between 500,000 and 600,000 people, the bulk of whom were sheltered in Red Cross camps, a total of 138 having been established during the emergency period. The flood swept through seven states in one of the richest agricultural regions of the country, creating a rehabilitation problem for solution after the water receded.

Before the latter stage of the work was reached, the relief forces had to contend with one of the most many-sided jobs conceivable, with ramifications scarcely realized by anyone, even those who actually saw the problem at the flood scene.

First, there was the emergency work of rescue, then sheltering and feeding an unprecedented number of humans of all degrees, made destitute in the common disaster. In itself, this was a huge task, in which various Federal and State agencies cooperated in such ways as the loan of aircraft from the Army and Navy; radio apparatus and operators from the Navy; rescue boats and crews from the Coast Guard; engineers from the Army; tents, blankets and other supplies from the Army; detachments of National Guards loaned for various purposes by the flooded states; and the services of Federal and State health officers.

Individuals volunteered their services in literally uncounted numbers and their work was monumental. Private organizations, business firms and nation-wide utilities, all assumed a share in the battle against the greatest disaster of the nation's history. All served under the Red Cross, which was accorded the leadership by common understanding, and in line with the Congressional charter fixing Red Cross responsibility for disaster relief.

To conduct this battle, the Red Cross raised at the summons of the President, and with the co-operation of the people of the whole country, a sum of more than $16,000,000, exceeding any previous fund ever raised for a disaster relief task in peace-time. Cost of administering this huge sum was borne by the National Headquarters of the Red Cross from its national funds, so that every penny of the relief contributions went for relief itself.

Mississippi Rehabilitation

As the flood subsided, the rehabilitation problem presented itself. These hundreds of thousands of people, who had lost their crops, their homes, their belongings of every kind, had to be restored to their normal plane of life. By hundreds and thousands, the Red Cross transported flood refugees back to their homes and farms, as the first step towards normal. During the flood, more than 200,000 head of livestock rescued in various parts of the disaster zone, were sheltered and fed by the Red Cross, and as their owners returned from camps, these animals were transported with them. Much of this return movement was made by water, animals and their owners traveling home by boat as they had traveled to camp in the early days of the flood. They took with them sufficient food for the family, and feed for the stock, to last until something like normal living was possible once more. The Red Cross supplied simple essentials of household furniture and equipment to replace necessities at home which had been destroyed in the flood. Farmers were given farm implements and garden seed for the family, and were given seed or plants for a new crop to replace the lost cotton or other plantings.

From the beginning of the relief, the Red Cross had mustered its health forces on a large scale, to combat a disease menace such as the country had never witnessed and scarcely realizes now, because the fight was successful. The refugees were protected in camp; the normal ratio of sick and injured were cared for by Red Cross doctors and nurses in the camps, or in the upper stories of their homes, as the cases demanded. Approximately 536,000 persons were immunized against typhoid and 161,000 vaccinated against smallpox. As the refugees streamed back into the deserted flood country, the Red Cross organized flying teams of doctors, nurses, and sanitation experts which followed up the receding waters, supervising the clean-up of mud-encrusted homes, purification of wells, checking up on inoculations, watching for epidemic diseases, and guarding the returning refugees' health in many other ways.

Still later the rehabilitation machinery grew from the organized relief forces of the Red Cross, composed of local and national personnel, contributed alike by the State and the National Red Cross organization. Rehabilitation was extended to the individual flood sufferer through State committees working in turn through county organizations, each with Red Cross representation, and all under supervision of experienced administrators of the organization who labored all summer in their field headquarters. Indicating the scope of this one phase of the relief, there were four such decentralized headquarters in the seven flood states, each administering the work in from one to three states.

Heroic Ills Demand Heroic Help

Like the actual work of disaster relief, the twin phase, disaster rehabilitation, was on a scale comparable to the size of the flood. One item called for 5,000 small homes to be ready-made according to specifications prepared by Red Cross authorities, and delivered in the disaster zone in knock-down form. These were for distribution to tenant farmers, farm labor, and small home-owners whose dwellings had been destroyed.

Caravans composed of workmen, with derricks, motor trucks, and other equipment, under Red Cross direction, went through the flood area locating homes which had been swept away, pulling them back to their proper foundations and setting them up again. These caravans made minor repairs on damaged homes and farm buildings, and helped "tidy-up" the various communities visited. The caravan is a regular feature of Red Cross operations following large disasters such as the mid-west tornado of 1925, the Florida storm, and similar catastrophes.

Besides replacing individual homes, the Red Cross undertook the rehabilitation of three whole towns which were so badly affected by the flood situation as to become problems in themselves. These towns were Columbus, Ky., Arkansas City, Ark., and Melville, La. Columbus is the town which was moved half a mile inland from the river bank, as a preliminary to further reconstruction steps; Arkansas City required that several hundred homes and buildings be restored to their normal streets after being scrambled about in the flood; Melville, La., was inundated with both water and mud, and had to be literally excavated.

In mid-summer, when the flood as a subject for news was being relegated to the inside pages of the daily papers over the country, and the people in the flood area were in the midst of the vast reconstruction problem, the Red Cross announced that its veteran relief directors would remain in the field, and they have remained all summer, making personal visits to remote little villages and towns still struggling to come back, guiding the local Red Cross committees in their work.

While disaster relief is one of the spectacular functions of the Red Cross, it has other services which also are active all through the year, such as those in behalf of disabled service men and their families, life saving and first aid instruction, public health nursing, and many others.

Its services are made possible through membership of the people. The invitation to join the American Red Cross and support its activities through membership the coming year, will be extended this year from November 11 to 24, in the Eleventh Annual Roll Call of membership.

The Work of the American Society for Testing Materials*

By W. H. FULWEILER

Past President, American Society for Testing Materials

I AM rather diffident about speaking of the work of the American Society for Testing Materials before the Engineers Club of Philadelphia; it is almost like carrying coals to Newcastle, when we consider how many of the members of the Engineers Club have been active members of our Society. Dr. Marburg, who was our first Secretary, and who was largely responsible for putting the American Society for Testing Materials where it is, was a member of this club. Two of its presidents, Mr. George S. Webster and Mr. Guilliaem Aertsen, were also presidents of the Engineers Club. Many of our past presidents have been members of the club—Mr. A. W. Gibbs, Mr. A. A. Stevenson, Mr. G. H. Clamer, Mr. R. W. Lesley. In fact, the American Society for Testing Materials is a Philadelphia product, and was born here. It was formed in 1902, so that at our next meeting we celebrate our twenty-fifth anniversary. In our chapter, the object of our organization is stated as, "The promotion of knowledge of the materials of engineering and the standardization of specifications and methods of testing." Of course, I personally feel that should be written just the reverse. It should be first studying of the testing, because it is only by testing materials that you can secure knowledge of them.

The Old and the New

The old engineering materials were relatively simple—brick, stone, timber—and the ancients did not bother very much about engineering laws. They knew nothing about the theory of elasticity; all the old columns were designed on the ground of artistic symmetry. But by many years of experience, they did arrive at empirical rules of construction that worked out very well. Of course, there is one thing we don't know. We don't know how many of their arches fell down before they succeeded in building one of the proper shape. We know only the successes; we do not know the failures.

It is very evident, however, when we consider this complexity of modern engineering material, that we are in a different class. It is quite startling when we think of the number of materials we use in engineering and the extraordinary diversity of their uses. It is therefore but natural that we must call upon all of the sciences to aid us in testing materials and, therefore, in acquiring knowledge of materials. Of course, our first goal is knowledge. We want to know what the fundamental characters of the material are, what it is good for. After we have acquired some knowledge of that, we then cast about to seek for what purpose it may be most useful.

The Work

The first thing we think of in testing materials is their resistance to deformation and external stress. As a result, testing machines of almost superhuman intelligence have been developed, many of them built here in Philadelphia. We can test the breaking strength of anything from steel to thread, automatically, and automatically record the deformation under the stress. We can test stone and wood. And again this strength, this resistance to deformation, underlies many other tests—the melting point of bituminous materials, the melting point of stone or refractory material, the slump test of concrete—they are all really deformation tests.

Then there is chemistry. When we first tested materials, chemistry was thought to be of fundamental importance. What was the chemical analysis of the materials? And it was of great importance for many years. But as our knowledge of materials grew, we began to find out that it was not necessarily the constitution of the material that was of importance, that is, the ultimate constituency, but it was the way these ultimate constituents were put together. I think that is very clearly brought out in the large amount of work which is now being done on the subject of metalloids in steel, and it has always been the case in the analysis of refractory materials. It is not the chemical analysis of the materials that determines their vlaue, but it is the way these chemical constituents are put together.

Electricity is another branch of physics which we call to our use. We use optical systems in determining the small changes in length in our testing machines to give us the most accurate and precise measurements. We use the spectroscope to determine accurately many characteristics of light which we could merely guess at before. The use of the spectroscope has enabled us to analyze some of these complicated alloys. We can determine quite accurately at present many of the alloying materials, almost quantitatively, in very short time. We use the index of refraction in determining characteristics of oils, the optical pyometer in determining high temperatures. Electricity has been used also to determine physical contact. We use the pyrometer in determining high temperatures. We use electricity also to determine the settling point of lime.

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*Address before the Engineers Club, March 29, 1927.

Of course, there are other types of electrical tests that have become of great importance; for instance, the dielectric strength test, which is largely used in insulating materials, such as insulating tape. The great development of radio has required a large number of tests, such as the dielectric constant of the insulating materials and the phase difference, which has become very important in the construction of condensers for radio work.

Magnetic testing is but another branch of electrical testing, and we all know the great advances that have been made in preparing ferrous alloys of lower hysteresis loss. Also, there is the development of "permalloy," which promises to be of such great importance in ocean cables. Then, of still greater importance is the use of magnetism or magnetizing currents, and the study of variations therein in the testing of finished articles, in the testing of rails and the testing of forgings. I think we may be proud that the United States has been in the forefront in this work. It shows considerable promise in the testing of materials in such a manner that they will not be broken or hurt in the test.

Almost immediately related to this is the use of the X-ray in testing. The X-ray has been a very powerful tool in the study of allotropic forms of material and the determination of the constituents of alloys, and again in the testing of materials. I think it was only a few years ago that it was first suggested using the X-ray to determine the presence of hidden defects in metallic castings. A half inch was about the thickest casting that could be tested. Now we can test up to about three inches. And if we could get a million volts across the terminals of the tube, we could test to ten inches. They have already produced one million volts in the electrical laboratories and there is no reason why we should not expect soon to have it for testing purposes.

In addition to these types of testing, there are others the Society is at work on. The resistance of materials to high and unusual temperatures and pressures, for instance. It has been well known that copper at about 350 degrees begins to lose some of its strength; ordinary steel, at about 450 degrees; cast iron, at 500; but, with the urge for higher operating pressures and temperatures in the central power stations, the mechanical engineer is wondering what will happen at 600° C. That brings in a whole new field of development in alloy work, to study the resistance of materials under these extreme conditions.

Another extreme set of conditions are met with in the cracking stills, in the petroleum industry. There we have high temperatures, high pressures and the presence of a large amount of carbon, and certain tests have had to be developed for that.

Another industry is that involving the synthetic production of ammonia, or the synthetic production of methanol. Here, in some cases, we have pressures as high as 15,000 pounds per square inch, temperatures as high as 450° C., and we have the presence of hydrogen under high pressures and other gases, such as nitrogen, which have a tendency to destructively affect the steel under those conditions.

But, on the other end of the scale, is the corrosion of, let us say, steel at ordinary temperatures, the corrosion of our steel mains and cast iron mains and lead cables in the ground, the corrosion of roofing under the ordinary atmospheric conditions.

Then we have another type of corrosion, corrosion of refractory material in the furnaces fed with powdered coal; in the glass pots; in manufacturing plants. Here we have a different type of corrosion, but it is essentially an engineering problem to determine methods of testing such materials so that we will be able to select what is best.

What For?

Well, suppose this work, the testing, has been completed? What is the reason for doing it? Essentially, as I said before, our goal is the knowledge of materials, because when we have knowledge, we can select those materials that are required for certain purposes. We can then set limits on the required properties, or, in other words, we can write a specification. We may determine our properties with scientific accuracy, but in my opinion the writing of specifications is an art. That is one thing to which the American Society has been devoting a great deal of attention; to developing knowledge of materials to the end of writing specifications. Of course, in developing the knowledge we had first to develop methods because it must be evident that we cannot discuss the results of tests with one another intelligently unless we have made those tests under similar conditions and unless we have standardized the methods of testing. The standardized method of test provides a universal language whereby testing engineers can intelligently discuss their results.

The Means

How can these things be done? How can we get the laboratory facilities which are evidently very expensive? It is by co-operation, the working together on the part of men in various industrial laboratories and industrial institutions. We have the work in the society divided up among 45 standing committees, and they in turn divided into about 300 sub-committees. As members of those committees, we have about 1500 of the leading industrial firms in the United States. There are about 2000 members altogether who are represented on these committees so that we have available for this work practically all of the leading industrial laboratories. We have the laboratories, the various departments of the Government, the Bureau of Standards, Bureau of Mines, Department of Agriculture, with its Bureau of Forestry, etc., so that it is possible by this co-operation to put a great deal of trained energy into this work.

The Results

As a result of all of this work, we have developed about 270 standard specifications for materials and standard methods of test. This may not mean a great deal to you, but it gives me an opportunity to explain how these things come about. In the first place, it is a fundamental rule of our Society that there shall be equal representation, on these committees forming standards, of the producing interests, the men that produce the materials, and the consumers, those that use them. It must be evident that the producer cannot be expected to know all about the requirements of the material that is used, but he does have the best facilities for knowing what effect processes have on the making of the materials. So when our committees are formed, producers and consumers are equally represented, so that they have an equal voice. Then, after they have arrived at their conclusions regarding the suitability of the method of testing or the specification that this material shall be purchased under, this is published as a tentative standard. In that way, we give notice to the world we anticipate making this a standard. After a year or more has passed, the tentative standard is again considered and, if accepted on letter ballot, is adopted as standard. In that way there is ample opportunity given for free discussion or any criticism.

I do not wish to talk on the value of standardization because I know you have heard that discussed many, many times, but I do feel the value of standardization is worth at least saying that it does select that which is best; it permits the concentration of the manufacturer on fewer articles to be manufactured; it permits the consumer and producer to talk about the same thing. And after all, 90% of our industrial disputes arise because the buyer and seller are not talking about the same thing. This also gives assurance to the producer his material will be tested in a known fashion.

Let me point out one thing. About 1910, when we first started work on road materials, there were some 27 different specifications for road binders. Every state, almost every county, and most of the cities, each had its own specifications. Today we have those reduced to about 4 specifications, so that material made to meet them will he received in almost any state. In 1910, there were seven different methods of carrying on the distillation test, which is one of the more important tests in road materials. Today there is but one method. It must be evident that, if we can so simplify and so standardize methods of testing that everyone will use the same method, it will certainly be worth while.

It Pays to Drive on Concrete

Average gasoline consumption was reduced from 521 to 454 gallons per car per year as a result of highway paving done in North Carolina in the year from July, 1922, to July, 1923, according to B. C. Frost, as quoted in a statement made at a recent meeting of the Northern California section of the Society of Automotive Engineers in San Francisco. This reduction of 67 gallons of fuel consumption per car per year amounts to a saving of $16.75 per car with gasoline selling at 25 cents a gallon.

Records of an automobile dealer in Illinois who operates a drive-yourself service and separates his cars so that some were operated almost wholly on concrete roads or hard surface pavements and others on country roads, showed, according to a statement by A. J. Eddy, a civil engineer of Berkeley, Calif., that the automobile owner saves an average of 2.4 cents a mile on the hard surface highway. The speaker also referred to an estimate made by Col. H. C. Boynton, formerly connected with the Portland Cement Association, that an owner would save 2.6 cents a mile by driving on concrete or other hard surface roads rather than on dirt roads.

Taking the mean of these estimates and assuming that the owner saves 2½ cents a mile and drives 5,000 miles per year, his saving would exceed $125 a year. Although no data were available on motor trucks, the saving may amount to as much as 5 cents a mile.

Not only does the automobile owner save money as the result of hard road construction, but the taxpayers of the county and state also save money in the long run through the building of durable types of highways. Mr. Eddy cited as an instance of this an oiled macadam pavement whose maintenance cost the city of Berkeley $1,645 a mile per year during a two-year period, while a pavement that has an 8-inch concrete base and an asphalt surface cost only $53 per mile per year for maintenance during the same period, which is only slightly more than 3 per cent of the other maintenance cost.

The Business Situation

We quote from the **Cleveland Trust Company Bulletin, edited by Col. Leonard P. Ayres, Vice-President:**

"THE most important business development of the past month is none that has not been reflected in the current statistics of industry or trade. It is destined nevertheless to play a most influential part in shaping the course of business activity during the coming months, and next year. It is the completion of the design of the new Ford car.

"In future years when the business history of 1927 is studied in retrospect, it will probably be the verdict of careful students of such matters that the general slowing down of business which has characterized the second and third quarters of this year was caused in no small measure by the shutting down of the great Ford plants. We are perhaps accustomed to thinking of matters relating to that particular automobile company as being comparable to similar developments in the affairs of the other leading manufacturers in the same field, and perhaps even as lacking something of the same general interest because the Ford shares are not dealt in on the stock exchanges.

"Such an attitude is far from being justified. The fact is that in of productive capacity the Ford Company comes close to being half of the automobile industry of the entire world. Its activities include the operation of railroads and fleets of vessels, extensive mining of coal and iron ore, lumbering, manufacturing of glass and textiles, and other varied industrial undertakings on a great scale.

"Last May it was announced that when it had completed the manufacture of 15 millions of its Model T. machines the plants would be closed down, and a new model developed. This was a step without precedent in the history of the industry. Its effect was something like what might happen if the United States Steel Corporation should suspend operations for six months, although not so serious. A number of competitors reaped great profits, but general business was adversely affected.

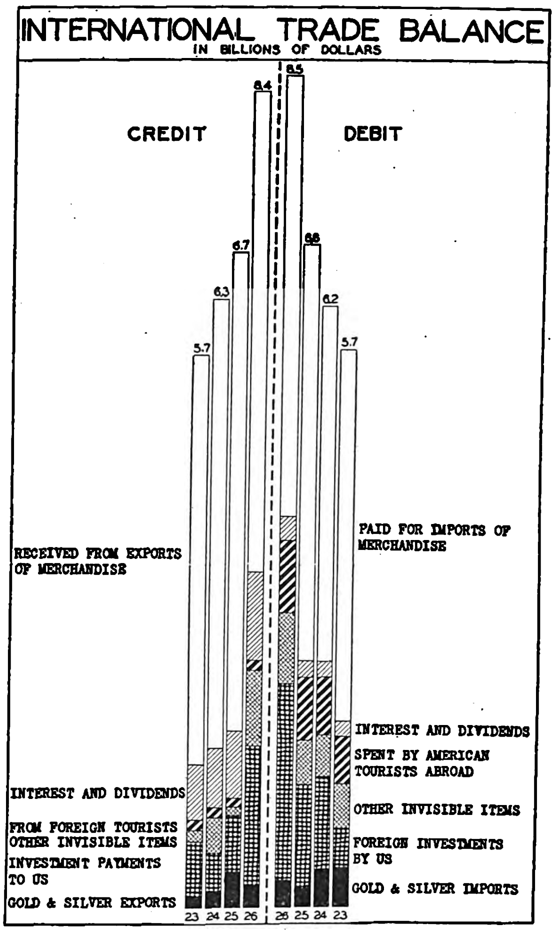
"The new models have now been completed, and some hundreds of thousands of orders for them have already been placed, and are waiting to be filled. Manufacturing industry throughout the Middle West will soon feel the stimulus of this new business, while railroad traffic, and wholesale and retail trade will be affected by it throughout the country.

"For some three months now the financial pages of the newspapers have been carrying interviews and articles about the expected pickup of business that was to come with the close of the summer season. It has been disappointingly slow in making its appearance, but when the new Ford models get into something like full production the industrial activity of the country will surely be largely increased.

"In most other lines business continues to move forward on an even course. Bank credit is in large supply at easy rates, and the prospects are that these conditions will be maintained for a considerable time to come. Building construction is still in large volume, and the prospects are that it will continue so as long as interest rates remain low. The prospects for a large holiday trade are excellent.

Our Trade Balances

"It is related that one of our public men in making an address some years ago in favor of a policy of national isolation asked the famous question, 'What have we to do with abroad?' The recent report of Secretary Hoover on our balance of international accounts for 1926 shows emphatically that we have a great deal to do with matters abroad, and that the importance of such affairs is growing with marked rapidity.



Courtesy Cleveland Trust Company

"The somewhat complicated diagram is the result of an attempt to show the comparative importance of the leading items in our international trade balances in 1923, 1924, 1925, and 1926. As in all balance sheets, there is a credit side representing the amounts received, and a debit side showing the amounts paid, but it is to be observed that our exports of gold and silver appear on the credit side, while the imports we received are on the debit side. This is a procedure that must necessarily be followed in drawing up such balance sheets.

"In commenting on the figures for 1926 Secretary Hoover points out that our place among the nations of the world is changing so rapidly that it is no longer possible to predict what the developments of the future will be. Our trade situation can no longer be judged by comparing our merchandise exports and imports, and our balances of gold shipments. The balances of the invisible items, such as investments, and tourist expenditures, have become the determining factors.

"We have become a great creditor nation lending vast amounts abroad through the purchase of long-term bonds. But we have also become a great short-term debtor nation, for we now hold large amounts of the deposits of other nations in our banks, and pay interest on them. This has completely altered our status with regard to gold shipments, for other countries send gold here for deposit, and such gold has not been sent as payment for merchandise. One most important result of that development is that no one can any longer make trustworthy predictions about gold movements which have most important effects on interest rates.

"Not the least interesting fact about these international accounts of ours is that the government economists find it necessary to make an allowance each year for the value of articles smuggled into the country. These merchandise imports consist in the main of liquors, and their value was estimated at 30 millions of dollars in 1924, and at 40 millions in each year since then.

"The first upright column on the left shows the credit items for 1923, amounting in all to some 5.7 billions of dollars. By far the largest item, represented by the portion in outline, was our receipts from our merchandise exports. The next lower section in cross-hatching represents the interest and dividends we received from our investments abroad. In similar fashion the four other principal classes of items are represented by the four lower sections of that column. On the other side of the diagram the last column on the right represents for the same year the corresponding items of our expenditures in other countries, or payments to them.

"The most important fact shown by the diagram is that the totals of our international accounts are growing so rapidly that the columns for 1926 are nearly 50 per cent taller than those for 1924. Moreover,—and this is the next most important feature—the rapid increase is not accounted for by growth in the volume of our exports and imports. The greatest increases are to be found in the investment payments, both those made to us and those made by us. The amounts spent by our tourists abroad are also mounting from year to year."

Items of Interest

The Philadephia Airport

The Philadelphia municipal flying field, which is known as the Philadelphia City Airport, is operated by a Board of Control consisting of the Chief of the Bureau of City Property, the Chief Fying Officer of the National Guard and a representative of the Ludington Exhibition Company, which Company has leased the field, and undertaken to operate it for a ten-year period. Time by automobile from the flying field to the center of the City is approximately 20 minutes.

The field is diamond shape, 3,500 feet long and 1,800 feet wide, the long direction being that of the prevailing winds. Its area is about 125 acres. There are four hangars on the field at the present time. The National Guard have one officer and fifteen enlisted men on duty at the Airport at all times. The Ludington Company have two large hangars, each with storage space for ships 92 feet by 70 feet. These two large hangars have a capacity for approximately 24 commercial ships. Both of these large hangars have concrete floors, one has heat, water and electricity, the other as yet has only electricity. There are woodworking and machine shops at the Airport, containing machinery to make any kind of repairs; a storage building in which all kinds of supplies are carried; a photographic studio for the use of air photographers; and a building, 40 by 80 feet, for the storage of oils and explosives in which the doping of wings will be done. The Atlantic Refining Company has put in a thousand-gallon tank for aviation gas which is equipped with special apparatus for the filling of airplane tanks directly from the pump. A small clubhouse has been erected on the field for the use of the Aero Club of Pennsylvania. The courtesies of the Club are extended to visiting pilots. The Clubhouse contains all comforts for the use of visitors, including sleeping quarters.

The field is a prominent landmark for aviators flying even at a high altitude, as it is between the Philadelphia Navy Yard and Hog Island and is close to the junction of the Delaware and Schuylkill rivers, which appear as broad, white ribbons to a flier. In addition to its ideal location and good approaches for a landing in any direction, the various landing field devices known to aeronautics, insure a successful landing.

Airplanes for Commercial Aviation

Airplanes will take the same place in transportation that automobiles now occupy, in the opinion of A. H. G. Fokker, president of the Fokker Aircraft Corporation, who contributed a paper on this subject to the September issue of The Journal of the Society of Automotive Engineers. Mr. Fokker says in part that the co-operation that commercial aviation is receiving from the Army and Navy in developing engines is very valuable. The Air Mail pilots deserve much credit that is not given them, and a person who receives a letter by Air Mail does not appreciate what it has cost the pilots in nervous force, knowledge and skill.

Airplanes have been developed to such an extent that, in Mr. Fokker's opinion, the machine itself is fully as safe as any vehicle operating on the surface of the ground. He says: "I never feel as safe in an automobile traveling 60 miles per hour as in the air at three times that speed, not only because of the possibility of breakdowns but because there are not yet so many fools in the air as there are on the ground."

Although the speed of commercial airplanes is a very important factor, they offer, in addition to speed, safety and comfort in the form of roomy cabins equipped with all the necessary things that are provided by railroad trains, including a heating system, a ventilating system, glass windows that can be opened and closed, and an aisle with room to walk between the chairs.

The safety of operation of airplanes is not merely a question of construction but of ground organization. The Government furnishes lights, maps and radio service to enable vessels that travel along the coast to complete their voyages safely, but it has not yet furnished the ground service needed by commercial airplanes.

For safety of operation, a good system of weather reports is necessary. The moment he starts, the pilot should know what the weather is along his entire route, and if there are adverse changes in the weather, he should receive the information during his flight by telephone, radio, or signal, so that he can return to his starting point or can land elsewhere than at his intended destination. To produce really efficient service in long-distance flying, it is Mr. Fokker's belief that a kind of block system, or a radio or telephone system, should be provided, so that the pilot can be communicated with at any moment and at any distance. Such systems are used on many of the airplanes crossing the English Channel from London to Paris and Amsterdam.

The extreme importance of night flying is causing intensive study to be made of the several problems not yet solved that will make possible safe operation at night during periods of thick weather and poor visibility, and when high mountains must be crossed. Intensive work is being put upon the development of instruments that will enable a pilot to keep his course and determine the position of his airplane in the air even though visibility is totally lost.

Landing on the fields at night is one of the greatest problems. A large part of the ground organization will need to come from the Government, according to Mr. Fokker, who says: "We are ready with our airplanes; we are ready with our engines; we are ready with almost everything else; but we are waiting for the Government to give us air-navigation service."

It is possible to build airplanes now that will not fall suddenly or cause the pilot to lose control even though the airplane loses speed. If stalled in the air, a modern airplane will not go into a sudden uncontrollable nose-dive or tail-spin, but will settle slowly on an even keel and the pilot can keep perfect control.

Three engines are used in the large airplanes, because the failure of one reduces the available power by only one-third, and will not necessitate a forced landing. The smaller the number of engines, the larger they must be to maintain flight under conditions of emergency, and the larger the engines the greater is the proportion they represent of the gross load of the airplane, with consequent reduction in the pay load.

Forest Fire Damage $27,000,000 Last Year—24,300,000 Acres Burned

Forest fires reported during 1926 caused direct damage amounting to about $26,900,000 in the United States, as the result of 91,793 fires which burned over 24,300,000 acres of the lands of the country.

More than 72 per cent of the fires are known to have been caused by man and 12 per cent by lightning. The causes of a little more than 15 per cent are unknown. Smokers lead all others as starters of forest fires with over 16 per cent of all; railroads come next with 13 per cent, and brush burning third with 12 per cent.

Mississippi, with 23,170, suffered more fires than any other state. Alabama was next with 14,953, and Georgia was third with 6,446. At the other end of the scale, Delaware had but 37 fires. Rhode Island 43 and Vermont 73.

Where protective systems were functioning in 1926, nearly 61 per cent of all fires were confined to areas of less than 10 acres, and less than 2 per cent exceeded 1,000 acres. Within the protected areas as a whole, the average fire burned 140 acres, as against an indicated average of 337 acres per fire on lands without protection. Of our total forest land area needing protection, only about 65 per cent is within the protected area, and the protection afforded ranges all the way from quite thoroughly fire-tight systems on some private, State and National forests down to the merest beginnings of educational preventive effort. On the protected area, there were 100 fires per million acres as against 308 fires per million acres of unprotected land. Only 1.21 per cent of the protected area burned while 10.4 per cent of the unprotected land burned over.

Within the areas under protection the 33,867 fires reported burned-over 1,040,000 acres of merchantable timber, 1,682,000 acres of nonmerchantable or immature tree growth and 1,394,000 acres with no tree growth at the time, the total area of forest land burned thus reaching 4,116,000 acres. Including the unprotected regions, 24,300,000 acres of land were scourged by fire during the year.

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Influencing Human Behavior—By H. A. Overstreet, Professor and Head of the Department of Philosophy, College of the City of New York; Lecturer, New School for Social Research. VIII. 296 pp., 5½"x8½". Cloth, $3.00.

"The following chapters are the substance of a course of lectures given last year at the New School for Social Research in New York City. In a number of respects the course was unusual. In the first place, it was requested by the students—men and women—and was given under the auspices of their Cooperative Association. In the second place, the manner in which the request was worded was significant. It came as a petition for a course indicating how human behavior can actually be changed in the light of the new knowledge gained through psychology. We have in our group educators, social workers, lawyers, business men and women, and those describing themselves as having no vocation. We have in common an interest in understanding and improving social conditions. Besides this, and perhaps first of all, we desire to utilize as a part of our everyday technique of action such knowledge as modern psychology can furnish us. Our interest is not academic. We wish actually to function with such knowledge as we may gain.

"The course was, to the lecturer, one of the most stimulating that it has been his good fortune to give. It strengthened his belief in the very great value (a value as yet scarcely realized throughout the country) of serious and systematic study on the part of men and women who can contribute out of the maturity of their experience to the ugrent problems of human behavior." From the Foreword.

Electric Power Equipment—By J. G. Tarboux, Assistant Professor in Electrical Engineering, Cornell University. 455 pages, 6x9, 374 illustrations. $5.00.

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All of these subjects are presented in such a manner that they are directly applicable to modern conditions. Selection of the most desirable methods, employed in this important work in various sections of the country, has been made.

The paper and binding were selected with unusual care. The paper was made to specification and the binding was chosen for its durability.

The Mineral Industry—Volume XXXV, 1926. Edited by G. A. Roush, formerly Associate Professor of Metallurgy, Lehigh University, and Allison Butts, Assistant Professor of Metallurgy, Lehigh University. 950 pages, 6x9. $12.00.

The latest technology in all fields and the statistics of production of all commercially important minerals made available many months ahead of other sources. It is the indispensable tool of every metallurgist, mining engineer and chemist. No industry has so complete and valuable an annual. It is an exhaustive review, not only of a statistical but a general nature. Every article is the work of a specialist. Every commercially valuable metal from aluminum to zinc is covered in alphabetical order fully and authoritatively.

Motor Vehicle Engineering—Engines, Their Design and Construction—By Ethelbert Favary, Consulting Automotive Engineer, Member, Society of Automotive Engineers. Third Edition. 363 pages, 6x9, 136 illustrations. $4.00.

The third revised and enlarged edition of a book that gives the latest information available on automobile, truck and tractor design. It represents standard American practice. It is based upon data especially gathered for this purpose from the leading manufacturers. It covers every phase of the subject in a clear, concise treatment that employs only simple mathematics. It presents working drawings of the leading manufacturers. Changes in the construction of engines brought about by the changed motor fuels are given close attention. Two new chapters, on fuel and detonation, and crankcase dilution, have been added.

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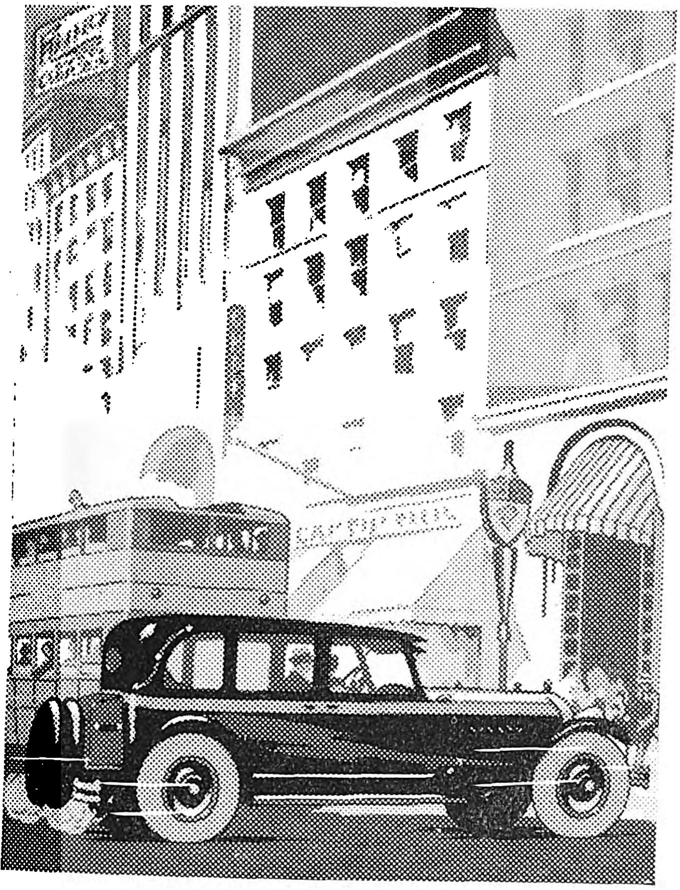

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(Continued on Page 278)

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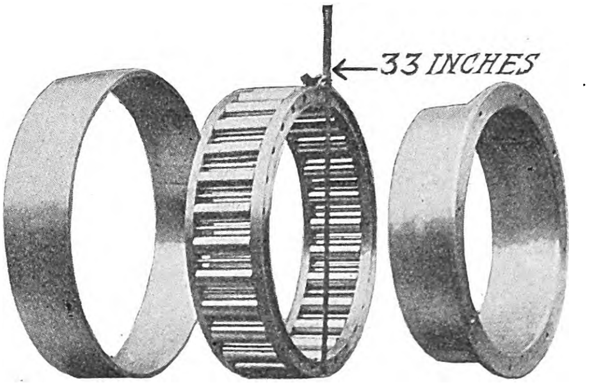

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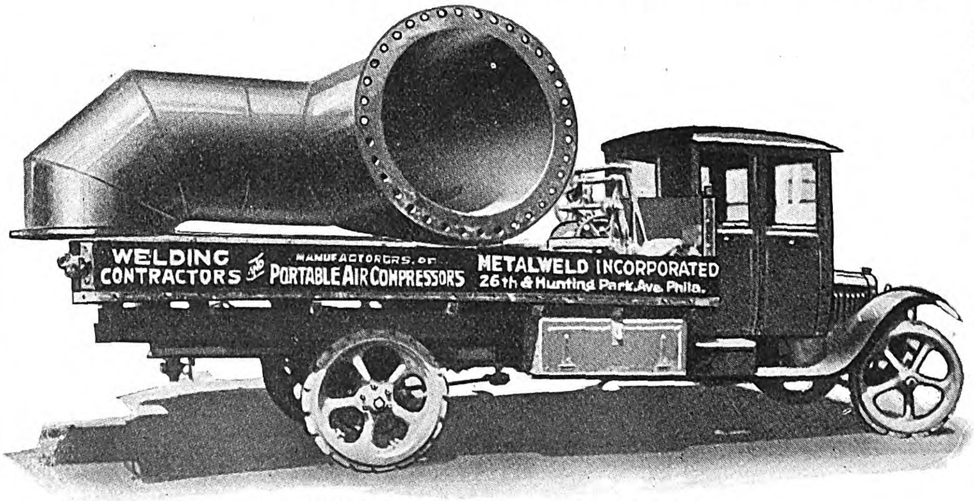
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ENGINEERS & ENGINEERING

NOVEMBER, 1927

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Vol. XLIV

No. 11

The Relation of Engineering to Architecture

Two papers, one by an eminent American architect, the other by an architect of Ireland, emphasizing from different viewpoints, the close affiliation originally established between the professions and the necessity of guarding against any estrangement.

Engineers and Architects*

MILTON B. MEDARY, JR.

President American Institute of Architects

I WANT to speak a little bit historically because I feel that the various phases that go to make up the building industry have, of necessity, due to the multiplicity of interests that cluster about it, been segregated and separated over the years. I feel, however, we have gone through that cycle and we suffer now —architecture particularly suffers—from the fact that we are segregated and are not really working together as we should. If you will go back to the great works like the cathedrals of the Middle Ages, you will realize that those were great engineering works as well as great architectural works. You will realize they combine not only the scientific but also the artistic, that each represents a complete co-ordination, complete co-operation between those men who were interested in the fundamental structural elements, those who were interested in the beauty of form and line, and those again who were interested in the metal crafts, mosaics, stained glass, metal work,—all those arts and crafts that, collectively, make up architecture. There isn't any architecture, worthy of the name, that is structurally sound and is not as well a great engineering structure. On the other hand, I don't hesitate to say that there is no great engineering work, likewise worthy of the name, that is not beautiful from an architectural standpoint.

Now these are the two principles that should guide our professions. I am tempted to paraphrase a remark of Mark Twain's, made when he was asked what he thought of Christian Science. He avoided making a direct reply and said if Christians knew more about science and Science knew more about Christianity, the world would probably be the better for it. I think that is easily true of the work we are doing collectively in the construction industry. If we on the architectural side knew more of the engineering, scientific side, and if those who are engrossed in structural, mechanical and electrical engineering knew more about, or thought more about, the beauty of line and proportion, of thoroughbred quality, we would have in our great public structures and our public works more of those elements which made the ancient city beautiful. I was impressed by hearing the President of Philadelphia Council say, a few days ago, he would like to see legislation passed preventing any man taking office as head of any department in Philadelphia, until he had spent some time abroad, at public expense, looking at the capitals of Europe.

But this segregation is a perfectly natural thing. The building of today is the result of a combination of a multitude of activities. Mechanical engineering, structural engineering, and so forth, occupy four-year courses in a university. Men are graduated thinking primarily in terms of the particular thing they have studied. What I want to stress now is the necessity for closer co-operation and closer co-ordination between all of these elements, if we are to have a great national architecture. Architecture doesn't exist by itself. It is really nothing more nor less than a co-ordination of many arts and sciences. We are suffering on the aesthetic side, even more than on the scientific side, from the fact that the same segregation has influenced sculpture, painting and many of the crafts. It is almost impossible today, or very difficult, to find a sculptor who thinks in terms of the whole structure. It is almost impossible now to find an artist or sculptor who is not thinking of his art as a separate thing. The picture or the piece of sculpture has to stand on a pedestal by itself, with the result that our buildings have been thin and poor and mean in comparison with the glorious array of every possible contributing art and science, which is represented in the buildings of the Medieval or Renaissance periods. We have been accustomed to think of the architecture of the Egyptians as only stone work. We know now that isn't true. All the arts were combined by them.

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*Address before the Engineers Club of Philadelphia, October 18, 1927.

I know it is more difficult to get a complete coordination today, when men are so completely absorbed in the several elements, but it isn't true in the medical profession, for instance. They have gone through the same thing; the old family practitioner no longer exists of the type you would trust to treat your ear or eye or throat, now you look to him for the protection of your general health, and expect him to put the best expert knowledge in special fields at your service. That is pretty nearly the job of the architect at the present time; he must call in all these specialists; and you as engineers of various kinds are absolutely necessary to the architectural profession, and I believe the architectural profession is absolutely necessary to you in all your great work.

Now when it comes to the question of long distance planning, I have tried to think of the particular necessity for this co-ordination and co-operation in what is known as regional planning. It has been my good fortune to be working in Washington both on the Fine Arts Commission and now on the National Capitol Planning Commission, and that Planning Commission illustrates, to my mind, what every city should have. At the beginning of its first session, the last Congress created the National Capitol Planning Commission. On it are the Chief of Engineers, U S. Army; the Engineer Commissioner of the District of Columbia; Col. U. S. Grant, who is the engineer-officer in charge of buildings and grounds; the head of the National Park Service; the head of the National Forest Service; and the Chairmen of the Buildings and Grounds Committees of the Senate and of the House; serving on it by appointment of the President. There are also Mr. Frederick Olmstead, landscape architect; Mr. Frederick Delano, who is the Chairman of the Planning Commissions of New York and Chicago; Mr. Nichols of Kansas City, who has developed real estate from the standpoint of a beautiful layout plus an economic and good investment point of view; and I was appointed the architect of that commission. All of us have been impressed with the great value of having all of these elements combined in studying the great problems of the National Capitol. The result of that happy family of interests has been that the Secretary of the Treasury has appointed a special committee to consider the treatment of the great public building program launched by the last Congress. Two buildings only have been authorized and these would normally have been built on whatever available land existed, without consideration of their relation to future building. The result, however, has been that, though money has been appropriated for the two buildings, Congress will be asked to provide for a survey of all the land from Pennsylvania Avenue to B Street, and from the Capitol to the White House, before any building is begun. Public officials in Washington have recognized the importance of looking far enough ahead so that what is done in any individual unit shall be part of a greater unit which in turn will result in creating major elements in a great city plan worthy of the nation's capital.

I believe that every city in this country should have just such a commission, made up of similar elements of personnel. Questions of transit, of bus service, of the handling of great numbers of government employees, surveys of every conceivable kind having to do with the functions of these particular buildings, had to be made with the greatest of care before any thought could be given to the general disposition of the buildings. This is equally true of all city planning. In other words, we must find the nature of our problem before we can plan its solution or design its physical form.

That sounds like a big order for many of our cities, but as a matter of fact, you can't do anything without planning. The simplest house is to be both planned and zoned. The legislature of Pennsylvania, when the recent charter was given to the City of Philadelphia eight or ten years ago, provided that the City of Philadelphia should have a planning commission and a zoning commission. Neither of those commissions has ever been formed. Nothing else we do in life goes ahead without having some definite plan. You can call it a policy, you can call it a charter, or constitution—anything you please—but something basic, some basic point of view upon which you must build your future, is necessary to anything. Our cities are perhaps the only things we have that grow just like Topsy. Now when you stop to think that, when you design a house, the simplest house, you zone it, you decide where your kitchen should be and where the living apartments shall be, the relation of one to the other—there is not an apartment in the City of Philadelphia that is not planned along that line—and that in a city, which is the collective home of all the people, where more planning is involved than for a single house, we have nothing, you will see the folly of it.

Here in our own city we have had the problems of the Delaware River Bridge, and the new railroad terminal of the Pennsylvania Railroad, both great city gates, similar to those entering Rome or Paris, or any great European cities. Practically nothing has been done, in our city, to take care of the whole problem of streets and transportation conditions that will result from the immense flow from these great gateways of the city. I doubt very much today whether you could put down on a piece of paper exactly what has been anticipated as a result of the Pennsylvania Station at one side of the city and the Delaware Bridge at the other, and recognize in it any intelligent planning to meet a problem of such importance to the city. Now if we had these planning and zoning commissions which were authorized ten years ago, that would't be the case, and I believe it is the duty of men like those gathered here, who are trained planners, to see that the city of Philadelphia does have some such definite program.

The mere economies of this type of planning are illustrated by a few very simple facts. If, for instance, the street railways were placed five blocks apart, these on heavily paved streets, wide enough to carry all commercial traffic and the shops and stores, with the streets in between having narrow roadways, lightly paved, devoted entirely to residence life, we would have safety, quiet and decent living conditions, and we would save perhaps more than 50 percent of the money that is spent in street paving. Today, due to lack of planning, every street is designed to carry trucks and transit lines and to provide sites for every kind of development. Proper planning would cut street cost in half, commercial and similar interests would be located where they belong, and the life and safety of the little children of the residential sections would be protected. We would also, by looking forward in our planning and zoning, reduce the immense cost to the city of the exploitation of land. We like to think of land values as very high; we are prone to think that high land values make the city important. As a matter of fact, every dollar added to the cost of a piece of land on which a man lives or does business, is a permanent charge against the city. Somebody must earn the interest on that extra dollar on that piece of land every day. That is what has led to the planning of satellite cities abroad, has led to the study of zoning, has led to limitation of height of buildings, because the height of a building not only increases the land value under it and adds to the cost of living there but also narrows the street. A building with six stories on a street like Chestnut Street, if increased to twelve, thereby produces a result exactly equivalent to cutting the street width in half. Then to widen the street it is necessary to take properties on each side and pay the increased value for them. It is this kind of thing that adds enormously to the cost of living in our cities, simply the lack of reasonable forward-looking planning.

On the question of public expenditures, if you consider a city that spends five or ten million dollars or twenty-five million dollars a year on public works, and multiply that by fifteen, it seems a colossal sum. When a city plan is presented with the statement, "This is a plan looking forward fifty years hence, its realization will cost fifty times ten million dollars or fifty times fifty million dollars," people say, "This is nonsense, a pipe dream." As a matter of fact, such a plan simply represents the normal expenditures of that city with normal increases, looking far enough ahead, so that when it does spend five, ten, or fifty million dollars, it spends it as part of a future development that will always remain useful, will be part of a systematic development of the city; whereas, if it spends it in haphazard fashion, as frequently is the case, it does not know but that within five years much may be abandoned and demolished before the bonds issued to pay for it are retired. So, from a financial viewpoint, as well as from consideration of logical and studied development, it seems unbelievable that our cities, which are so careful to operate legally in conformity with basic charters, and where the courts are so careful to see that each ordinance passed is in accordance with that charter, should be permitted to develop physically without the slightest rule or regulation, wasting money, and the lives and safety and comfort of the citizens, simply through lack of reasonable forward-looking planning.

Architectural Engineering*

By R. M. BUTLER, M.R.I.A., F.R.I.B.A.

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THE title given to this paper, or rather informal talk, has been chosen for want of a better. When honored by being asked to read a paper, the author felt that he had little justification for accepting, his work and experience being mainly of an architectural character; however, he put certain ideas forward that may perhaps provide a change from the continuity of learned and scientific papers that come before you so regularly. It is said that "all work and no play makes Jack a dull boy," so the effort may, perchance, serve a use, interest you for a short while, and provoke some discussion and criticism.

It has often seemed to the author somewhat strange that the modern engineer has devoted comparatively little attention to the appearance, the æsthetic value, of his great compositions, or, what is of more importance, to the truthfulness and expressiveness of his designs: that is to say, to making the whole structure freely express its purpose and its construction. In many instances this is so, but in many others it is not. Now, many progressive architects are today talking of this subject in relation to their own work, although it is doubtful if their finished compositions equal their ambitious ideals. Until comparatively lately, architects have expressed their ideas in the terms of a past architecture. For some centuries it was all done in a form of revived classical architecture, the Orders of architecture: columns, capitals, bases, cornices were all part of the stock-in-trade, modified and adapted to suit every conceivable demand, utterly different from the uses of the Greek and Roman temples and the still earlier works, from which they were derived; then came the Gothic revival, the application of mediæval forms and details to purposes equally divergent from those of their originals. The Greek temple and the mediæval church are alike far distant from the demands of modern society. It is today recognized by many, that while tradition, which is the accumulated knowledge of the past, is by no means to be cast aside, the indiscriminate use of the forms and details of ages long past, designed for completely different purposes, is not logical, and efforts are being made to find new expressions evolved from modern construction and conditions—not very successfully, it must be admitted, but still something. The architect has, however, this excuse, that in essence he is fulfilling requirements that, in some respects at least, do not differ so materially from the needs of two or three hundred years ago. Churches, houses, town halls are still needed. They are still built of stone and brick, even if concrete has to a certain extent superseded those materials, and the unimaginative architect employs concrete—and even ferro-concrete—in an imitation of stone, negligent of the fact that he has a new building material that may open up a fresh epoch in design, as it has done in construction, if the architect can but avoid separating construction and design.

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*Extracts from a paper read before the Inst. of Civil Engineers of Ireland, published in Vol. LII of its Transactions.

Now, what has the engineer been doing the while? A substantial body of opinion has held that the future of constructional design in general may lie with the engineer, rather than with the architect. That it is the engineer, not the architect, who is creating new forms of construction and adapting them to modern requirements;* that the architect will eventually be crushed between the upper and the nether mill-stones of the engineer and the commercial decorating firms. The author does not believe it; the properly trained architect will always have a value to the community for his skill in planning and construction, and for the cultivated taste that he should be able to bring to bear on design. In ancient and mediæval times, and almost to the nineteenth century, there was no distinction between the engineer and the architect. The Renaissance architect was the engineer as well; he planned bridges, fortifications, harbors, etc. We first begin to hear of engineers not much earlier than the middle of the 18th century in France, and not for some time later in England. The architects were the engineers of those days. The highly specialized demands of the nineteenth century brought out a new class of men, whose aims and objects are well defined in the Charter of this Institution. These early engineers did not largely spring from amongst the architects; they were mostly men of a different type, mechanics and the like, whom the new demands of the times threw back on their own resources, and forced to evolve and actually invent forms and methods of construction. The architects, who until then had been also the engineers, did not respond to the new demands; these were altogether outside their scope.

The earliest structures of which we have knowledge, that can be described as involving engineering skill, are the Pyramids. They are, of course, always classed with architecture, but the late Lord Armstrong observed of them, that the construction was so massive and some of the stones were of such size and weight that it would tax the ingenuity of the modern engineer to move them; so we may bring them within the range of ancient engineering achievement. Then, we have the irrigation systems of Babylon and Assyria. These must have been of a very elaborate description, judging from the records. We know, too, from Sir Arthur Evans' discoveries in Crete, that the palace of King Minos at Knossos (2571-2340 B. C.) possessed, 2,500 years before Christ, a complete sewerage system on, comparatively speaking, the most modern lines, superior to any sewerage system until almost modern times. In the Assyrian palace at Khorsabad* and in Rhameseum at Thebes, systems of drainage and water supply (Rhameseum, 1436 B. C.) were in existence, and here we find the laminated arch, almost fifteen hundred years before Christ. The results of the excavations of the combined expedition, organized by the British Museum and the University of Pennsylvania, to Mesopotamia have disclosed discoveries at Ur that prove that the ancients, some 2,500 years before Christ, knew how to roof halls by arching and vaulting, thus requiring our histories of preclassic architecture to be re-written.

If we look back to Roman times, we see great engineering feats; the roads, the remains of which still exist, made straight from point to point, just as the modern engineer, providing for motor traffic, would make them, and with which the Romans intersected whole countries. The great bridges and aqueducts; perhaps we may take the Pont du Gard in Provence (B. C. 19) as an example, one of the finest Roman aqueducts existing. This great stone structure, originally 25 miles in length, passes over the River Gard and is about 900 feet in length, with three tiers of arches and three levels rising to 180 feet above the river. It was designed to convey a supply of water to the City of Nimes, the whole of that part of Provence being a Roman colony, where today the finest Roman remains outside of Rome itself are found. The aqueduct is a beautiful, as well as a practical, construction: it is a perfectly truthful expression of the material in which it was done, stone laid dry. It is curious that every one of the many spans of which it is composed is different, and that on plan it represents a curve—not up-stream, but down-stream. The theory of the late Professor Goodyear, M. A., of

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*Bronze reinforcements were known to the Romans, and ties and iron chains embedded in the masonry of the mediæval builders.

*The palace of Sargon, father of Sennacherib, in Mesopotamia.

Brooklyn, N. Y., is, that many of these variations found in ancient and mediæval work were deliberately introduced for effect, to break the hard look that a series of absolutely equal features might have had. Be this as it may, it is a fine expression of stone building; the elements of the design that afford strength and support are all apparent, and within certain limits, are perhaps as logical and satisfactory a solution of the problem as could be devised. The Romans well understood the value of a good water supply. Eleven great aqueducts provided Imperial Rome with a supply, computed at 350,000,000 gallons per day, and the upper floors of the houses were supplied with water by pipes.

The modern system of lighthouses does not go back much further than two or three hundred years, but the history of lighthouses is said to extend over 2,000 years. The Pharos of Alexandria dated from 331 B. C. The Romans built lighthouses at Ravenna, Ostia, and other ports. The Phoenician lighthouse at Corunna was repaired during the reign of the Emperor Trajan, and reestablished as a lighthouse in 1634; in 1847 it had a dioptric apparatus placed in it, a rather interesting survival of an ancient lighthouse. At Dover and at Boulogne (A. D. 40) are, or were, remains of Roman lighthouses. These early lighthouses had on their summits grates, or chauffers, in which wood or coal was burnt. Such lights survived in Scotland till 1816, in England until 1822, on the Baltic so late as 1846. Oil lamps were used at the end of the 16th century, but candles of tallow or wax were often used. Smeaton's Eddystone was lighted by a chandelier with 24 candles, each 2 pounds in weight. His account of the business of the Eddystone lighthouse, published in 1813, is exceedingly interesting. The Tour de Cordonan, on the coast of France, 1610, was a gorgeous affair by Louis de Foix, architect. The various orders of architecture were used externally and internally. It contained a magnificent "King's Apartment," richly decorated. The method of illumination was by a fire on the top stage, which ultimately calcined the walls and led to the demolition of the tower. The first lighthouse on the Eddystone rock was a wooden polygon 100 feet high (1696-1700), with a stone base, but the great storm of November 20th, 1703, swept it away, together with its designer, Winstanley (who is described as "the architect"), while executing some repairs. Another lighthouse, also of wood, was built 1706-9 with a stone base and 92 feet high by Mr. Rudyerd, who was a silk-mercer. The lighthouse, of conical shape, was described by Smeaton as pure shipwrights' work. The next, noted for its strength and the engineering skill displayed in it, was constructed by Smeaton, 1757-59. Smeaton himself says its shape was modelled on that of an oak tree! A rather extraordinary idea—one would have supposed that the curve in the outline of the structure was dictated, if not by mathematical formulæ derived from scientific observation of wave action, at least from some study of the effect of the waves; but no, Smeaton not only tells us the story of the oak tree, but also gives us a picture of the tree itself! Smeaton's lighthouse survived for over 120 years, until 1882, when the new lighthouse was built, and the old one taken down, the upper part being re-erected on Plymouth Hoe, where it stands a monument to this sturdy old-time designer, who had begun life as a law clerk, and started in London as a mathematical instrument maker in 1750, only five years before he undertook, at the age of thirty, the formidable task of designing and building a lighthouse on a lone rock in the sea; but "The Lives of the Engineers" furnish many examples of strange and courageous beginnings. One wonders how many young law clerks or instrument makers of today would venture on such a task as Smeaton's, in spite of all the textbooks, formulæ and accumulated knowledge now available!

It is remarkable that few of the old engineers sprang from the ranks of the architects, but rather from the mechanic class. Apparently the architects of the eighteenth and early nineteenth century, who had hitherto performed the work of the engineers, were so engrossed in the study of Greek and Roman antiquities, and the niceties of minutes and modules and of due proportion, that they were unaware of the enormous changes being wrought by the introduction of machinery and by the development of trade and commerce, and were unable to meet the demands of the day; so the engineers were recruited from the mechanical class, and a young law clerk and instrument maker successfully did what they were unable or unwilling to do.

From the illustrations in Smeaton's book showing his own and the two previous lighthouses, we can see what an ornate edifice the first one was in the days of "Dutch William." The upper part is of wood, but the designer committed the solecism of imitating in timber the stone construction below. The lantern is a fine, showy affair, with its cupola roof and gorgeous iron vane! The designer was evidently well acquainted with the architecture of the day, with its Dutch influence. Rudyerd's lighthouse was not so pretentious, but still quite a respectable affair in appearance. Smeaton's lighthouse is thoroughly constructional in form, and the material is rightly used in spite of its derivation from the oak tree. Its shape seems to have influenced lighthouse design for a long time.

Men like Smeaton, Rennie, Telford, Stephenson, Fairbairn, and others became engineers more by accident or force of circumstances than by deliberate design. Sir Guildford Molesworth, that grand old man of the engineering profession, describes William Fairbairn, to whom he was apprenticed, and who made all the elaborate experiments and performed all the calculations for the novel Britannia Bridge, as follows: "Sir William was a splendid example of a class of men, then numerous in the manufacturing districts, who by their energy and intelligence had improved their position from that of a workman to that of an employer of labor on a large scale. He came to Manchester without a penny in his pocket, but from working on piecework, and then taking petty contracts, managed to scrape together enough money to start a tiny wheelwright's shop on his own account; this he did so well that by degrees he added three other huge establishments to his works in the vicinity of the original workshop. He died a baronet, a wealthy man, and F. R. S." This was the type of man from whom the engineers of the eighteenth and early nineteenth century were sprung.

When we examine the stone bridges illustrated by Gauthey, we see that they are sound and truthful in construction. We may, of course, dismiss such uncertainties as the Persian and Chinese fantasies that he took on trust. In all the stone bridges of old time, the material is rightly used, the arch fulfills a function proper to it. Such ornamentation as is used is simple and effective, suited to the material. Gauthey illustrates a number of timber bridges which speak for themselves. It is difficult to misuse timber unless we imitate in it some other material, and we get some interesting examples, and may, perhaps, learn something from them.

Neither steel nor reinforced concrete were known in the early nineteenth century; but iron was a new material, and lent itself, especially cast-iron, to many structural uses. Traces of the use of iron in the construction of bridges in Italy in the sixteenth century have been found, it is said. In 1755 an iron bridge of three arches of 25 metres span was designed for Lyons by Désaguliers, but was not built.

The Coalbrookdale Bridge over the Severn (1773-1779) was the first bridge to be constructed of iron; it was by John Wilkinson and Abraham Darley, Iron Founders, and the parts were cast at Coalbrookdale. Gauthey illustrates this bridge. Other iron bridges followed, both in England and in France, and it must be admitted that these early iron bridge designers showed remarkable skill in handling a perfectly new material for this purpose. The Coalbrookdale and the Sunderland bridges strike one as graceful and the treatment as logical for the material. The stone abutments are harmoniously managed. Even our own much-abused Metal Bridge is not without attractiveness. These early iron bridges owe much to their fine curve and considerable rise, which is inconvenient for modern traffic. One wonders have we exhausted the structural uses of cast-iron? It seems a material that still has possibilities about it. The design for the Pont d'Austrelitz at Paris avoids the high curvature of the early examples, and is a logical and decidedly pleasing utilization of the material. It may be interesting to note that the fluted columns of the Greek Doric portico at Castlebar Courthouse, designed by George Papworth about 1835, are of hollow cast-iron, while Francis Johnston, the architect of the General Post Office, St. George's Church, and the Chapel Royal, Dublin Castle, who ought to have known better, made the elaborate Gothic window tracery of the latter building, finished in 1814, of cast-iron, a barbarous misuse of the material! Years ago, some Dublin architects protested against what they called the "vandalism" of painting the tracery, but the officials of the Board of Works were able to retort that they knew of no other means of preserving cast-iron!

Concrete and Ferro-Concrete

The use of Portland cement, invented in England by Joseph Asplin in 1824, was preceded by the use of natural cement. In America, natural cement was first used in the Erie Canal, begun 1817, and the Americans used imported English Portland cement until the early seventies, when they began to make Portland cement for themselves. It was not until this century that they, to any extent, provided themselves with home-made cement. So late as 1905, 10 per cent. of the cement used was still imported. It is strange that it is only within the last few years that any attempt has been made to give distinctive expression to structures of concrete or ferro-concrete. The invention of Portland cement and its use in concrete has developed in two directions: (a) in mass, (b) through the discovery of the effectiveness and economy of steel and concrete in combination. It is plain that mass concrete, speaking broadly, used in considerable bulk, demands for its proper expression large, bold design. It will appear most effective when treated broadly and semi-plastically. For its suitable handling, some of the ancient forms, such as Egyptian, with their great battered walls and massive pylons, offer some suggestion. Reinforced concrete, on the other hand, demands a quite different treatment. Its essential quality is, the economy of material, combined with strength, and the design, without any effort, is strongly articulated. Hence, its natural form (and every material should be used according to its natural form) is a sinuous, attenuated type of design, not unlike the tracery work of the developed Gothic of the Middle Ages, when the east end of Gloucester Cathedral had become a vast wall of glass divided by tracery bars. The development of design in reinforced concrete, so far as relates to the emergence of a definite type and form of design, has not progressed very rapidly; we have, however, some examples of its practical and pleasing use. A couple of churches have been built in France which have been much admired by some architects and other artists, though the author considers them ugly; the best known is the church at Raincey, near Paris. Another instance is the new chapel of the Naval Academy at Annapolis, Md. Both these buildings are obviously reinforced concrete building plainly expressed as such. The material is not a moment in doubt. The architect of the naval chapel is Mr. Ernest Flagg, but the design of the essential structural elements is clearly an engineer's. The designers of the Raincey church were two brothers, architects by profession, but also acting as contractors. They designed the whole of the work themselves.

One of the important factors in reinforced concrete is its great tensile, as well as compressive strength. To a certain extent this introduces a new element in construction and design; the element of wide spans on thin supports, which of course this material shares with structural steel.

Steel

Exposed steel is another material which has possibilities of artistic handling. When wrought-iron beams first came into use, much was said and written on the subject of making the system of construction decorative. Purists declared that beams and stanchions carrying the main substance of the building must never be covered, but must be left exposed in all their nakedness; designs were published that now seem to us very weird. This was carrying truth in art pretty far—the bones of the human frame are not exposed, but we all know they are there. The theorists of this school proceeded on a false principle; they attempted to ornament the beams and stanchions with scrolls, fanciful roses at the rivets or bolts, filled-in spandrils with fancy ornament, etc. It was all wrong, because the ornament was strange and foreign to the material, and really had no relation to it. Better encase the steel and made a column of it, because the column with its base, shaft, and cap expresses the function of vertical support and transmitted load. You see also an example of the successful handling of exposed structural steel by McKim, Meade and White for the Pennsylvania Railroad Station, New York, 1905. In many other cases cast-iron, fashioned in the form of stone construction, was applied or fastened on. There is no doubt that if design is allowed to proceed naturally in the way that the economic and practical development of the material dictates, we shall ultimately, not immediately, attain a certain purity of form, not necessarily of the type to which we have been so long accustomed. It has been explained of some of the new forms of architecture, that it may be freely granted that they are not beautiful as were the forms of old time, but that it is unreasonable to expect newly developed forms to have the same beauty as the centuries' old types to which we are accustomed. The motor car is a good illustration. When first introduced, the new "horseless carriages," copying, or rather caricaturing, the fine lines of a barouche or a Victoria, appeared to us inexpressibly ugly. But the practical motor engineers, whose one aim was efficiency and economy, by degrees evolved a form which is perfectly suitable for its purpose, structural and beautiful. No one could call a modern Rolls-Royce, with its fine streamline body, ugly, and we have, moreover grown accustomed to it.

The Britannia tubular bridge over the Menai Strait is an instance of the successful use of a new material and form in the solution of a difficult engineering problem. The result was not merely one of the greatest engineering triumphs of the day, but an æsthetic success.

You will recall that the problem was to bridge the Strait for the new Chester and Holyhead railroad. It involved such great spans, and there were so many difficulties, that Stephenson conceived the idea of a wrought-iron tubular bridge in two spans of 460 feet each, the tubes being made self-supporting. The unsuitability of cast-iron for such long spans was felt; the longest span in cast-iron, Southwark Bridge, did not exceed 240 feet. Stephenson's original idea was to use cylindrical tubes, and he was with difficulty diverted from it by William Fairbairn, who conducted the elaborate series of experiments for him, and who claimed the credit for the rectangular section ultimately adopted. He and Stephenson, unfortunately, fell out over this. Be this as it may, the tubular idea was a completely new one; it involved much anxious thought and sleepless nights before certainty and success were attained. These men, moreover, were not content with solving the bare structural problem, but gave their great continuous tubes a fine setting and support in the massive pylon-like towers in which the tubes are carried, more than 100 feet above the water. The towers are finely designed—bold, strong, battered structures. The author does not know if the carrying of the towers above the level of the tubes fulfills any structural purpose, but it adds immensely to the dignity and gives an appearance of strength to the whole conception. It is a happy blending of the old and the new materials, the traditional time-honored stone, still fulfilling its ancient task of bearing the great load, the new wrought-iron fulfilling its novel function. Men of less imagination might have simply built cast-iron piers to carry the tubes or, worse still, introduced petty architectural decoration. The entrances to the tubes, with the bold pylons and the great lions, are fine. The vast scale of the whole thing makes it impressive.

The Conway tubular bridge, by the same authors and built about the same time, is not nearly so satisfactory, because they fell into the error of adapting a sham Gothic castellated form, adapted from the adjacent Conway Castle, for their towers or pylons, which at once vulgarizes it in comparison with the Britannia Bridge.

Bridges and viaducts are indeed a fascinating subject, there are so many varieties old and new, and all have their charm. Suspension bridges and cantilever bridges are very interesting, too, elegant examples are the Menai Straits Suspension Bridge and the Clifton Suspension Bridge. Some of the suspension bridges are very graceful. The great Forth Bridge on the cantilever principle is impressive, but loses effect by the awkward junction of the cantilever sections with the beamed sections.

In his recent posthumously published book entitled "Architecture," Sir Thomas Graham Jackson seeks to define what architecture really is, and much of what he says might be applied to the æsthetics of engineering.

Having referred to the transition from the mere building of the barbarian to architecture, he asks, "What has been added? Certainly not ornament. An idea has been added. Reason has been brought to bear upon practice, and this influence once begun, and carried on with advancing skill, is the secret of all that followed." When we recall the building methods of the Egyptians, the Greeks, and those of the mediæval master-builders, amongst others, we realize how much truth there is in this reflection of Jackson's. He points out the eagerness of the architects of Egypt, Greece, etc., to reinforce their buildings with color; the mere use of surface decoration, however, he concludes, had no influence on the architecture. "The æsthetic passion that inspired the decoration, fired the architect as the necessities of construction and convenience demanded new features, and novel details and fresh additions to the simple building. These now became not merely practical structural features for purposes of utility, but matters that were capable of giving pleasure or the reverse, according as they satisfied the æsthetic sense or not. The cornices were projected in graceful curves, the huge pylons were proportioned agreeably and tapered as they rose, the art of sculpture was combined with architecture, capitals took new forms," and so on.

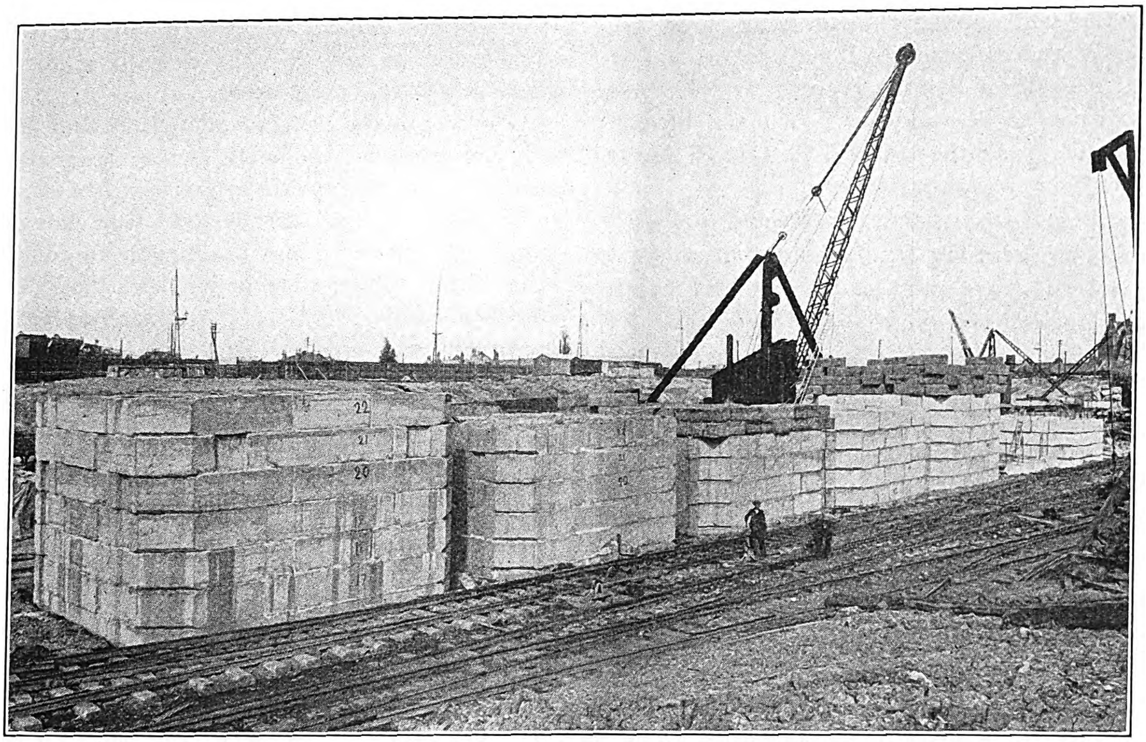
Architecture, as Sir Thomas Jackson tells us, thus developed from structural necessities, "not by the addition of ornament to structural form, but bending the structural forms themselves into forms of beauty. Architecture is construction, but construction inspired by a new spirit."

It may indeed be taken as an axiom, that where the engineer is content to let his design be truthfully expressed, and to speak for itself, no matter what the material, it will attain at least dignity and simplicity, if not absolute beauty. The quality of beauty must be attained through form, and not through applied ornament. The overlaying of a utilitarian element with purely decorative ornament or detail is fatal to repose. The concealment of structural and functional engineering works beneath an architectural cloak is worse; it is, moreover, a degradation of the engineer's genius. The Tower Bridge, London, is an example of this. Here we have an engineering structure, fine from a mechanical point of view, the achievement of a great engineer. The bascule, or drawbridge, is apparently carried by a showy Gothic tower on either side, designed by an architect who had no association with the structural problem, and without giving a vestige of a hint of the real mechanism concealed within—that does the work. It is therefore a sham. Apparently the conception originated in the idea of the mediæval keep and drawbridge, but the conditions are wholly dissimilar. In a scheme for such a bridge there is opportunity for highly original thought and design. Let us contrast the Tower Bridge with the elegant simplicity of Waterloo Bridge, by Rennie, generally considered to be the most beautiful bridge in Europe, condemned, alas, in spite of all protest, to be destroyed, unless the Royal Commission—appointed as the result of international protest—succeeds in saving it.

Now, as to the question sometimes discussed: the possibilities of co-operation between architect and engineer, these are strictly limited; the requirements for success in either calling have become so specialized and so divergent that to practice either successfully demands a life time of study. There is a certain necessity for the engineer's help in architectural practice that is now well recognized; in reinforced concrete construction, in the solution of any problem involving vast span, exceptional or novel structural difficulties on a great scale, etc. The steel frame work and the foundations of all the skyscrapers and much lesser structures are, and will continue to be, designed by engineers, but any closer co-operation is impracticable.

As to architects assisting engineers in their designs, there is little scope for this. To attain dignity, the engineer's design must develop from itself. Wherever architects have been called in to superimpose an architectural dress, it has been a failure. This does not mean that architects should not design the buildings arising out of engineering works, such as railway stations, railway hotels, etc., which are in their special domain, or may not be consulted upon form, mass, or detail of engineering structures.

Each calling must work out its own salvation; the problems of the engineer in a prosperous and progressive modern community grow daily more important and at the same time more interesting, and will in the future afford opportunity for structures that, by their scale, vitality, and truthful structural handling, will convey an idea of great impressiveness.



CONCRETE BLOCKS BEFORE SINKING

Recent British Port Development*

By BRYSSON CUNNINGHAM, D.Sc., B.E., F.R.S.E., M. Inst. C. E.

Lecturer on Waterways, Harbours and Docks in the University of London

THERE has been considerable activity of late in the development of shipping accommodation at British Ports; several important schemes have either materialized to the point of completion, or have been definitely embarked upon. After a long period of comparative stagnation, there is being manifested the recrudescence of a spirit of enterprise which has largely been in abeyance since the War and, more particularly, during the period of acute depression in shipping affairs, which succeeded the boom of 1919-20.

London

London, to commence with, has a varied and extensive programme of improvements in hand. A new dock, the Quebec Dock, has just been completed for the timber trade at the Surrey Commercial Docks. It has a water area of 15 acres, and provides five berths, each 400 feet in length, as well as the requisite complement of sheds and roadways.

Not only has the timber trade quite recently been provided for, by the Port of London Authority, but the interests of the refrigerated meat trade have also received equal attention. An addition to the existing accommodation has been made by the construction of a new reinforced concrete quay, forming a shipping berth on the north side of the Tidal Basin, Royal Victoria Dock. It is 456 feet long and, with an adjacent berth and recess, gives a total frontage of 750 feet, with a depth alongside of 30 feet below the normal impounded level of the dock. The quayside facilities for handling meat carcasses are of the most modern description.

Then, as regards general accommodation for large-sized vessels of the Atlantic and Far Eastern routes, the Port Authority has just embarked on an ambitious scheme for providing a floating landing-stage for passengers at Tilbury, in conjunction with the service of the Midland Railway from that station to London, thereby securing rapid transit for passengers to and from the metropolis and the point of embarkation or disembarkation.

But this enterprise is small in comparison with the general scheme for the enlargement of accommodations at the Tilbury Docks. The items to be dealt with, first in order, are a new entrance lock and a new graving dock. The present entrance lock has a length of 700 feet, an entrance width at Trinity high-water level of 80 feet, and a depth over the outer sill of 44 feet below the said datum. The graving dock will have proportionate dimensions. It will have a length of 750 feet, capable of being increased to 1,000 feet when this proves to be necessary, with an entrance width of 110 feet, and the sill will be laid 37 feet 6 inches below Trinity high-water level.

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*Substance of an address delivered to some members of the Engineers Club, June 28, 1927.

The new dry dock is being constructed in a position adjoining two existing dry docks, and at an angle thereto, in order to leave room for expansion in length. The present docks have lengths of 700 feet and 560 feet, with entrance widths of 73 feet 6 inches and 62 feet 9 inches respectively, at Trinity high-water, and sill depths of 35 feet and 30 feet below that level.

The methods of construction and the nature of the accommodation being provided at Tilbury present certain features of interest. The types of quayage, or berthage, here, as at other British ports, is quite different from the system of projecting piers exemplified at Philadelphia and characteristic of most American ports. Owing to the range of tide, which reaches 20 feet and upwards, shipping at London is received into enclosed basins, or wet docks, in which the water is impounded at a fairly constant level approximating to high water in the river approach channel. This, of course, necessitates entrance locks with gates, bridges and operating machinery, involving expense in construction and maintenance which is not incurred at the majority of American ports, where the tidal range is small, and, in fact, in many cases is scarcely recognisable.

The wet docks are constructed on land behind the river embankment, the walls being designed as solid gravity structures capable of resisting the earth thrust in the rear. Owing to the defective nature of the strata at Tilbury it is not practicable to construct the walls within timbered trenches, and they have to be built by means of so-called "cylinder" or well foundations. The well consists of a series of vertical blocks of concrete with hollow compartments, four in number. These are built up in courses upon a bottom "cutting edge" of reinforced concrete. The blocks are laid on the ground and gradually sunk by excavating the soft earth from the interior compartments by means of a grab, what in America would be called a clam shell bucket, suspended from the jib head of a crane and operated by means of the crane winch. Sinking is assisted by blocks of cast iron kentledge laid upon the concrete blocks until they penetrate to the firm gravel bed lying below the mud and peat. The principle of construction will be best understood by reference to Figure 1, which shows the "cylinders" in the graving dock, lock, and quay walls, when sunk to the required depth. The "pockets" in the "cylinders" are filled, after sinking, with concrete, or in some cases, are sealed and left empty.

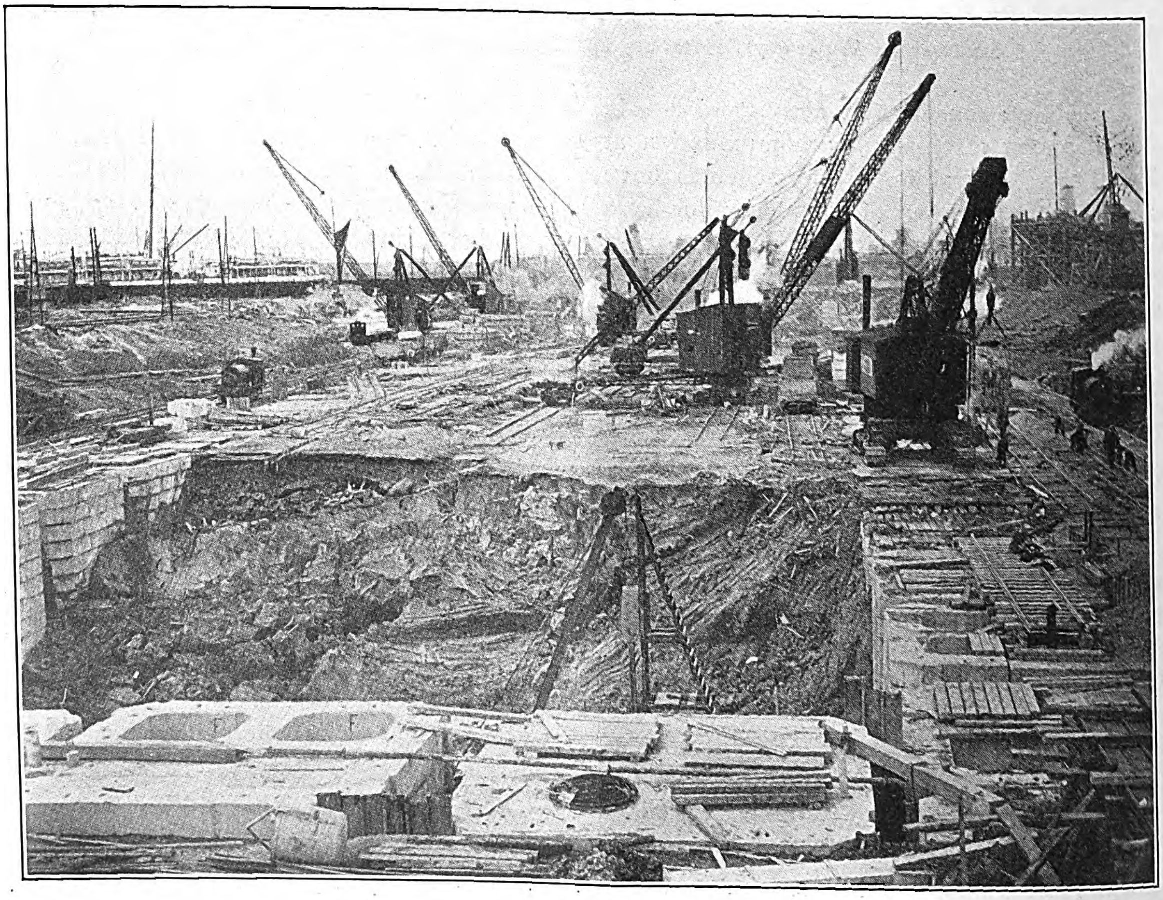

FIGURE 1

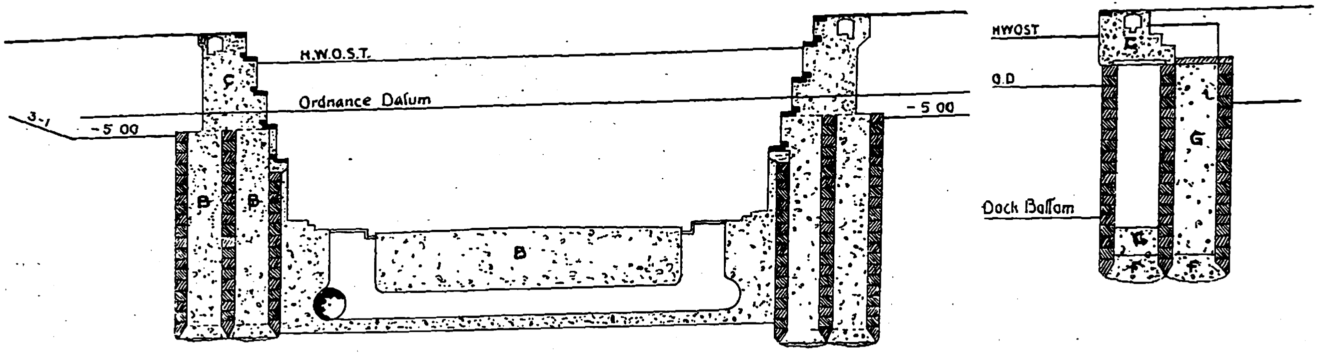

FIGURE 2

The other figures illustrate other phases of the construction. The figure at the head of the article shows the blocks piled in preparation for sinking; figure 2 is a reproduction of a drawing showing sections of the basin through a drain and of the dock wall with full and empty pockets. Figure 3 is another general view of the work in progress.

The graving dock and entrance lock are estimated to cost £2,750,000, which with £1,400,000 for the floating stage, makes a total outlay of over £4,000,000 to be expended within the next four or five years. The financing of such a project would not have been feasible at the present time but for assistance given to the Authority under the Government Unemployment Grants Scheme.

Despite their magnitude, the foregoing items do not exhaust the activities of the Authority in improvement works. At the India and Millwall Docks, there is in hand a programme of work which comprises the construction of a new entrance to the South West India Dock, 590 feet long by 80 feet wide by 35 feet deep at Trinity high-water, and the cutting of passages between the West India Docks and the Millwall Dock, which will enable the largest vessels capable of navigating so far up the Thames to proceed to and from any part of the India-Millwall dock system. Substantial progress has already been made with this work, which was commenced about a year ago, particularly as regards the communication cuttings and the remodelling of the railway sidings on the south side of the South-West India Docks.

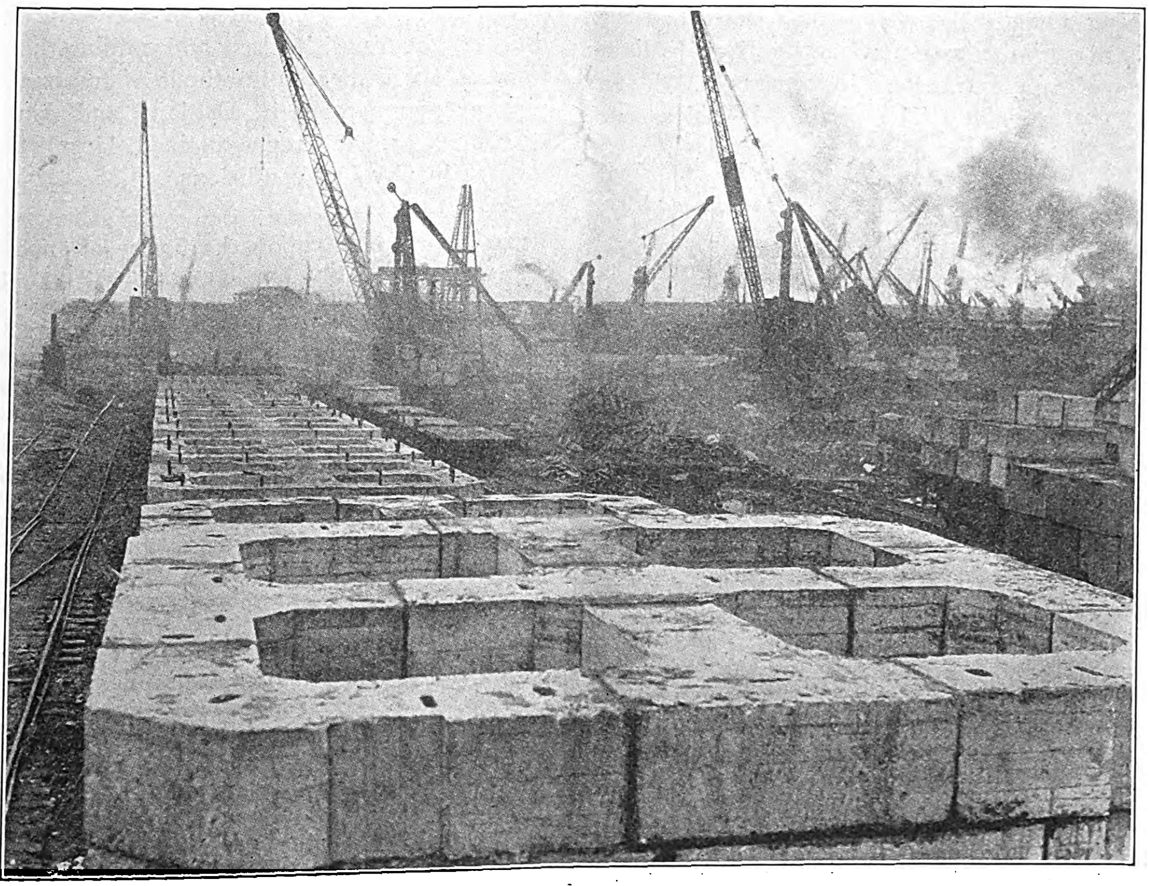

FIGURE 3

Liverpool

The Port of Liverpool is on the eve of a striking event in its annals—namely, the opening in July, next,'* by H. M. The King, of a new system of docks, adding nearly 60 acres of water to the enclosed accommodation of the port, with three miles of additional quayage. The system in question is the Gladstone Dock and its two branches at the north end of the Liverpool estate, where it links up with the existing Hornby Dock. It incorporates a graving dock, which is the largest in Europe, and which has been independently in use since 1913, until its recent absorption into the main system.

This undertaking on the part of the Mersey Docks and Harbour Board will have cost about £7,500,000. The river entrance is remarkable as consisting of an exceptionally large entrance lock, 1,070 feet in length and 130 feet in width, divided into two compartments, having sills 20 feet below Liverpool Bay datum, or 30 feet below the Liverpool "Old Dock sill" and so affording a depth of 48 feet 4 inches at high water ordinary spring tides, or 42 feet 9 inches at high water ordinary neap tides. The tidal range at Liverpool is about 20 feet at neap tides and 30 feet at spring tides.

Inside the entrance is the vestibule, or turning dock, named the Gladstone Dock, after a former Chairman of the Board, with a water area of 25 acres. It serves to connect the two branch docks, as well as to afford communication with the Hornby Dock, by means of an intermediate lock passage, 645 feet long and 90 feet wide. The combined shed area on the North and West Quays of the vestibule dock is about 3¼ acres.

The two branch docks are arranged parallel to each other and extend in an easterly direction from the main dock. The Gladstone Branch Dock No. 1, the more southerly of the two, is 1,420 feet long and 400 feet wide. It is equipped with three-story sheds on the north and south sides, aggregating nearly 32 acres of floor space, including the flat roofs, which are designed to take light loads. The Gladstone Branch Dock No. 2 is 1,285 feet long and 400 feet wide. This dock is similarly equipped with three-story sheds aggregating nearly 23 acres of floor space including the roofs. The sheds in both cases are of reinforced concrete construction and are provided with electric cranes and other appliances for the rapid handling of goods.

The Gladstone Graving Dock has a length of 1,050 feet and an entrance width of 120 feet. The depth of water over sill at high water ordinary spring tides is about 43½ feet. A curious feature of the dock is the fact that it can be used as a wet dock as well as a dry dock.

It would take too long to detail what is being done at other notable ports, such as Bristol, Southampton and Glasgow, with various improvements at the Tyne ports, Belfast and elsewhere. The foregoing particulars of the work carried out, or embarked upon, at the two leading British ports will suffice to convey some idea of the nature of operations on the English coast and exhibit the difference between the respective methods of treatment of shipping accommodation in England and America, due, of course, as has been explained, largely to the difference in physical conditions.

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*The dock has since been duly opened and is now in operation—Sept., 1927.

The Oil Situation

In the last few weeks the Bureau of Mines made public its computation of the production of petroleum in the United States in 1926, and the figures, 770,874,000 barrels, constitute a new record.

Due to the increasing production abroad, particularly in Venezuela, which nearly doubled its output, the United States produced a smaller proportion of the world's oil than in 1925, its percentage declining from 71.5 in 1925 to 70 last year. The total world production is placed by the Bureau at 1,096,000,000 barrels, an increase of 27,000,000 barrels over 1925.

The total value of the crude petroleum produced in this country was $1,447,760,000, and the average price per barrel was $1.88, an increase of 20 cents per barrel over 1925. The prosperity of the industry in 1925 has not been maintained in 1927, owing to excess production, and particularly to expansion in Oklahoma and Texas, where the area of oil-bearing territory was greatly extended.

Notwithstanding the enormous volume of present production and the rapid increase in the demand for petroleum products, Mr. J. C. Wellion, of the American Petroleum Association, makes the following reassuring comment upon the future of supplies:

> Inevitably, the problem of assuring ample supplies of petroleum over a long future is of keen concern. From the beginning, there have been epochs of anxiety, predictions of shortage. Yet demand gains by leaps and bounds, and supply keeps pace. There have been at times threats of over-production, at others of shortage. But economic factors have always wrought corrections; if there is over-production, prices presently tend downwards and production decreases; if under-production, prices move upward and furnish the urge for an increase of production which restores the balance. Constant discovery of new fields, deeper and ever deeper drilling, larger recoveries from the oil-bearing sands, more efficient refining, and the cracking of a constantly greater proportion of the heavy oil—all these things have kept supplies in pace with demand. It is now realized that if ever the supply of well oil definitely sags, there is an almost inexhaustible resource at hand, in the oil-bearing shales, which are scattered throughout many states, and in the distillation of oil from coal. Scientists, technologists, government initiative, and the industry's interest have united in the research and investigation which seem to assure against a motor-fuel famine.

The Conowingo Hydro-Electrical Development

Two Papers and Discussion (Condensed) Presented at a Meeting of the Philadelphia Section, American Institute of Electrical Engineers, October 10, 1927.

I. MELVILLE STEIN,
Chairman of the Section, Presiding

The Project

By N. E. FUNK,

Assistant Chief Engineer, The Philadelphia Electric Company

THE part of the program I am going to present is the general over-all picture of this hydro-electric project, and Mr. Hentz will then follow with some of the general mechanical details of the dam (because that part links in with the design better than it does with a general survey of the project) and will carry that through to the electrical end of the job,

The map shown in Figure 1 is not directly related to the project; it shows the general interconnections of 220,000 volt lines with the Pennsylvania Power & Light Company and Public Service Company of New Jersey. The Conowingo project is connected by two 220,000 volt lines to Philadelphia, at Plymouth Meeting, just north of Conshshocken. A transmission line is run to Roseland Station, near Newark; another, to the Siegfried Substation near Allentown; and a third, to the Delaware River near Bushkill, and thence to Roseland. There is a tap at Bushkill to the Wallenpaupack Hydro Plant of the Pennsylvania Power & Light Company. Later, there will be two 220,000 volt lines through Frackville to Sunbury. This gives you a general idea of how our hydro-electric project ties into the central eastern region of the Atlantic Seaboard power supply.

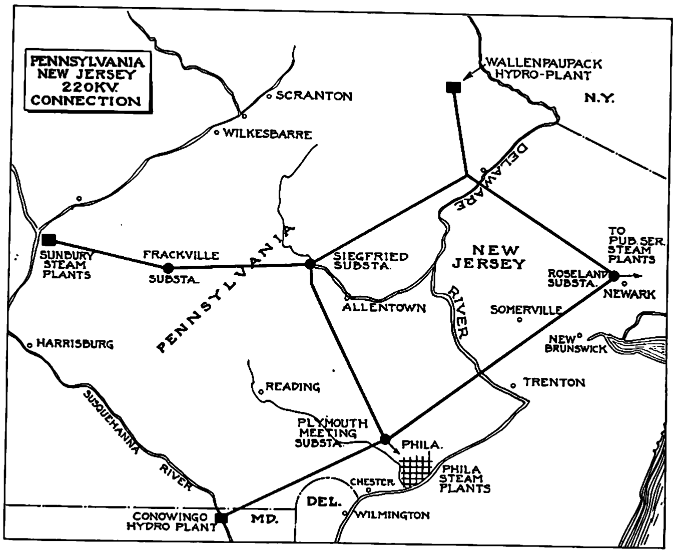

PENNSYLVANIA NEW JERSEY 220KV. CONNECTION
SCRANTON
WILKESBARRE
WALLENPAUPACK HYDRO-PLANT
N.Y.
DELAWARE
SUNBURY STEAM PLANTS
FRACKVILLE SUBSTA.
PENNSYLVANIA
SIEGFRIED SUBSTA.
NEW JERSEY
TO PUB. SER. STEAM PLANTS
ROSELAND SUBSTA.
NEWARK
ALLENTOWN
RIVER
SOMERVILLE
NEW BRUNSWICK
HARRISBURG
READING
TRENTON
SUSQUEHANNA RIVER
PLYMOUTH MEETING SUBSTA.
PHILA.
PHILA STEAM PLANTS
CHESTER
DEL.
WILMINGTON
CONOWINGO HYDRO PLANT
MD.

FIGURE 1

Figure 2 shows the Susquehanna watershed, 27,400 sq. miles in area. The area outlined is the drainage area of the Susquehanna River. The Conowingo plant is near the northern border of Maryland. The drainage area is divided as follows: Maryland 1%, Pennsylvania 77%, New York 22%.

The storage basin back of the dam is fourteen miles long, from the dam to the tail race of the present McCall's Ferry plant. There are about fourteen square miles in this pond.

The Port Deposit and Columbia Branch of the Pennsylvania Railroad connects Perryville with Harrisburg, and is on the eastern bank of the Susquehanna. This road will be flooded when the dam is closed, and it was,

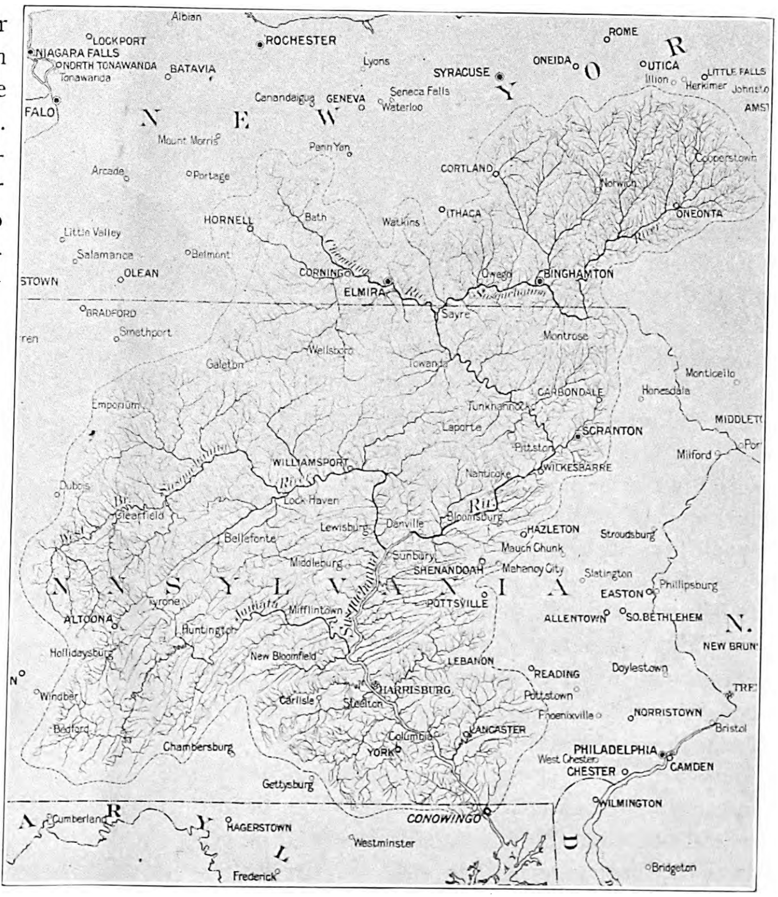

ROCHESTER
SYRACUSE
ROME
UTICA
ONEIDA
NEW YORK
CORTLAND
ITHACA
ONEONTA
HORNELL
CORNING
ELMIRA
BINGHAMTON
OLEAN
BRADFORD
Sayre
Montrose
Wellsboro
Towanda
CARBONDALE
SCRANTON
WILKESBARRE
WILLIAMSPORT
Lock Haven
Clearfield
Bellefonte
Lewisburg
Sunbury
SHENANDOAH
POTTSVILLE
HAZLETON
ALLENTOWN
EASTON
SO. BETHLEHEM
ALTOONA
Huntingdon
Mifflintown
PENNSYLVANIA
HARRISBURG
LEBANON
READING
Carlisle
Steelton
Columbia
LANCASTER
YORK
Chambersburg
Gettysburg
NORRISTOWN
PHILADELPHIA
CHESTER
CAMDEN
WILMINGTON
CONOWINGO
HAGERSTOWN
Westminster
Frederick
MARYLAND

FIGURE 2

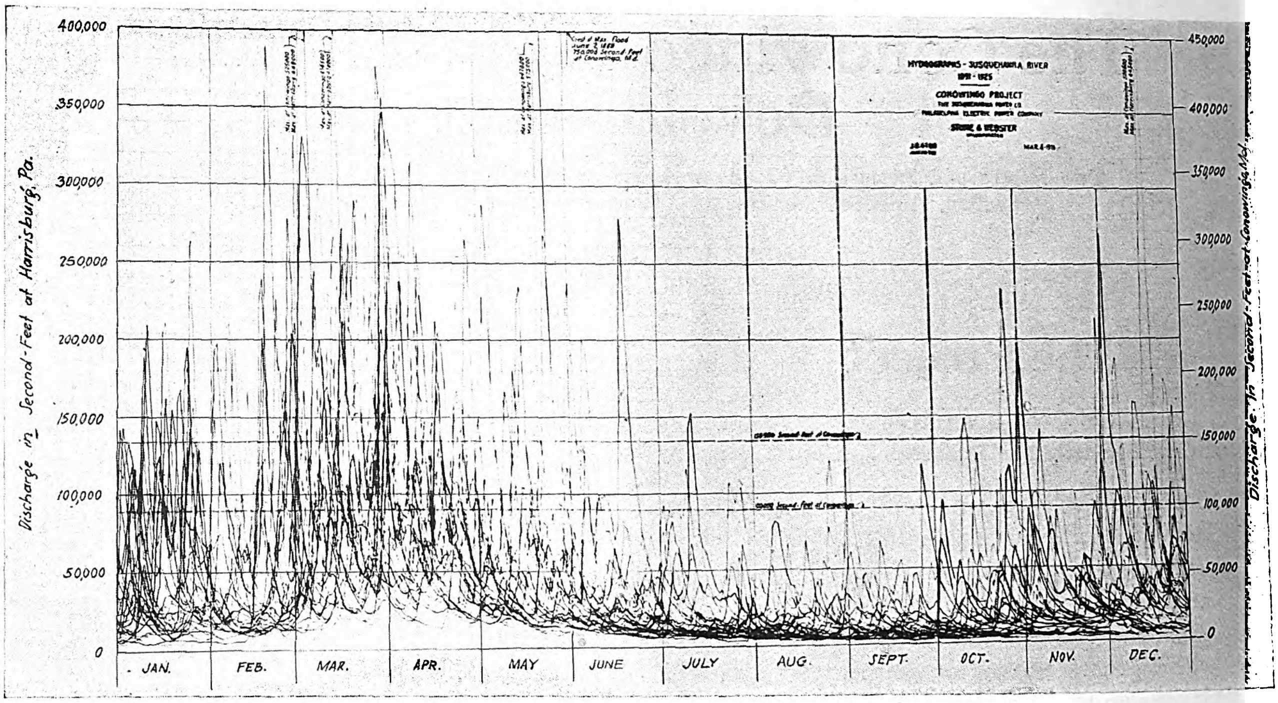


FIGURE 3

therefore, necessary to change its location, from just below McCall's Ferry to Port Deposit. It also was necessary to relocate Baltimore Pike.

The variation in river flow is shown in Figure 3. Records of 31 years have been plotted on this chart, superimposed on one another, which is why it looks so very ragged. The highest flow was about 750,000 second-feet, occurring at the same time as the Johnstown flood, but not caused by that flood directly, since the river at Johnstown does not empty into the Susquehanna; it was due to the same water conditions, the same rainfall that caused the Johnstown accident. The next highest flow was about 650,000, or 100,000 second-feet less, and around 400,000 second-feet seems to be a fair average to expect. The dam is so designed that, at flood period, the wheels and the flood gates will pass about 880,000 second-feet, which is well above anything known on the Susquehanna River. You will notice the great irregularity which must be contended with; the low flows during many days in the summertime, and exceedingly high flows during the spring and even through the summertime, at intervals, and in the late fall.

There are many wondering why the development of the Conowingo project is now possible, when financiers and engineers, who have been working on the project for about forty years, had heretofore come to no satisfactory conclusion which promised profitable operation. The situation, so far as the power available is concerned, is still practically unchanged from what it has been in all that time; the situation, in so far as the availability of the power is concerned, however, has greatly changed. When there is sufficient water in the river to permit the operation of the wheels at full capacity for twenty-four hours a day, they operate in conjunction with the steam plants in Philadelphia, in the manner shown in Figure 4. The cross-hatched section is the amount of power delivered from the hydro-electric project. Notice, that when the peak load in Philadelphia is about 620,000 K. W., all the power cannot be absorbed for the full twenty-four hours; the interconnections

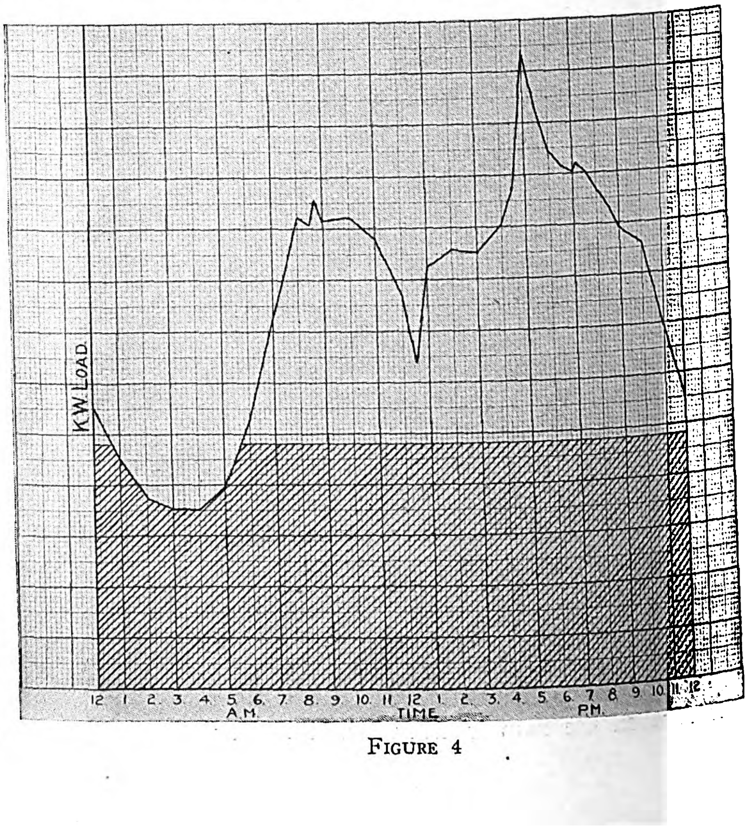


FIGURE 4

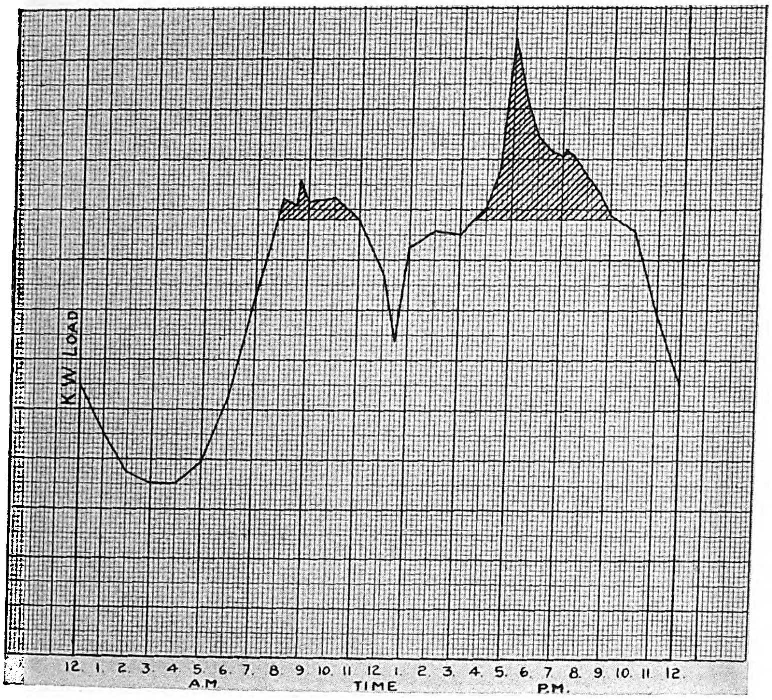


FIGURE 5

will absorb this excess.

There is also a period when there is not sufficient flow for full use of the plant capacity. At such times, the hydro-electric plant operates in the manner shown in Figure 5, that is, the steam plants carry all the base load and the hydro plant carries the peak load, and is shut down for the remaining hours of the day. Assume, as an actual example, that there is sufficient water in the river at the low flow to provide for a load of 20,000 K. W. for twenty-four hours a day. Now, if it were possible, by a method of operating the plant in a block load fashion, to generate uniformly for eight hours, you would have three times as much maximum capacity and could carry a 60,000 K. W. load instead of 20,000 K. W. Still further, with a peak of the kind shown in Figure 5, which is approximately triangular and whose area is consequently half its altitude times its base, the same area is included in a triangle of 120,000 K. W. peak while maintaining the eight-hour base. If the time during which the plant is operated is less than eight hours, the peak that may be carried is proportionately increased, because the area of the triangle represents K. W. hours or the equivalent water consumption and this area is maintained constant by increasing the altitude of the triangle as the base decreases.

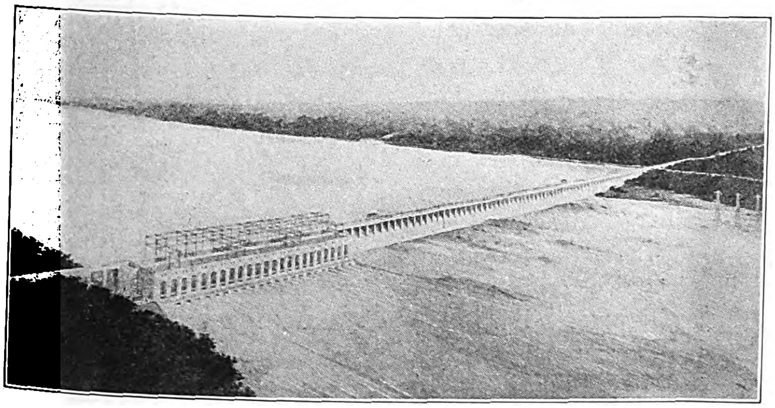


FIGURE 6

Figure 6 shows a general view of the dam. It is in four sections: the headwork section of the plant on the left; the spillway for the regulating gates taking care of the small stream flows, next; the long spillway, which takes care of floods, third; and then the flat backed section, which merely serves to carry the dam to the rock wall on the east side. The construction was carried on in sections. On the river bottom the dam is continuous but, from an elevation of 22 ft. above sea level, alternate sections are built up to their full height and carry piers to hold the roadway. This has to be carried over the dam before the latter is completed, since when the flow of the river is shut off, the present Conowingo bridge, to be superseded by the roadway, will be flooded. The river, therefore, was allowed to flow between the alternate sections during the building-up process of the dam.

Electrical Features

By R. A. HENTZ,
Assistant Electrical Engineer, The Philadelphia Electric Company

THE title refers to electrical features, but I felt that engineers are interested in the general engineering problem as well; and therefore some description of the dam and the water wheels, as well as of the electrical equipment, will be given.

Continuing from where Mr. Funk stopped, the architect's plan of the power house and dam is shown in Fig. 7. The power house can be seen on the left-hand side (which is the west). It is laid out for eleven 36,000 K. W. machines. Next are the three regulating gates; then come 50 crest gates; and then the section that extends between the bank of the river as it is and as it will be after the level of the river has been raised. To the right is toward Philadelphia, and to the left toward Baltimore. On Rowland's Island are located the towers for the 220 kv. lines. These lines extend from the plant to Rowland's Island and then across to the east bank of the river.

There are five different cross sections of the dam, and these are shown in Figs. 8 to 12. Fig. 8 shows where the four future units go. Stop logs are inserted in the passage to these wheels as shown. The gantry crane, which raises and lowers the regulating gates, is shown on top. Fig. 9 is a section at the regu-

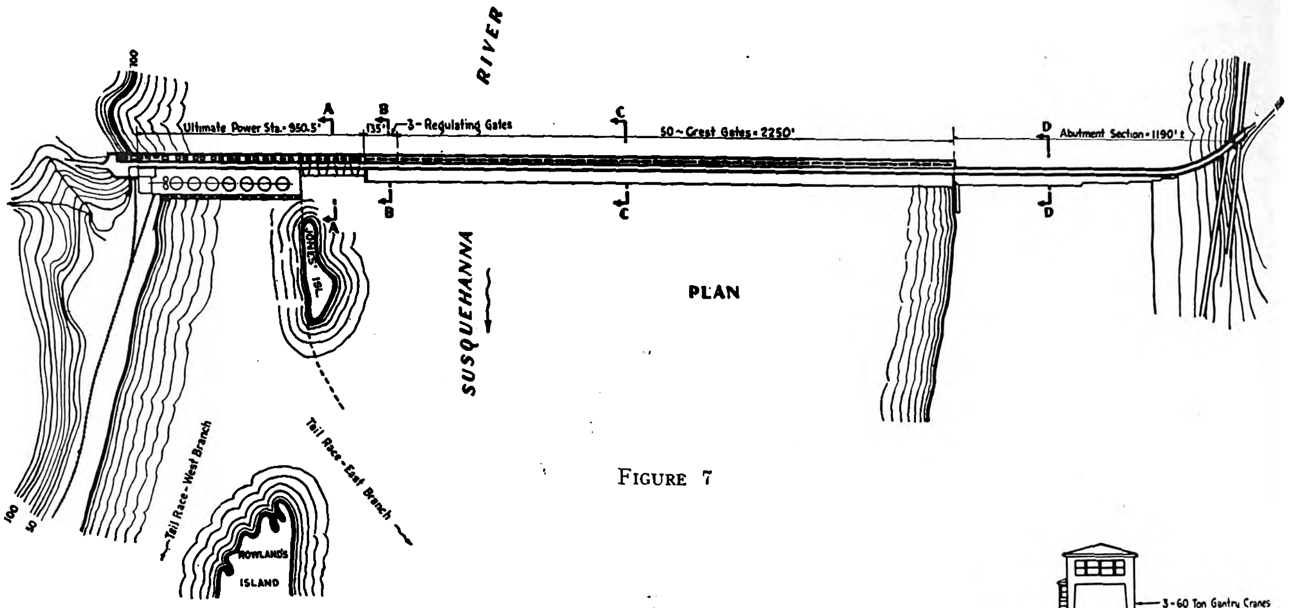
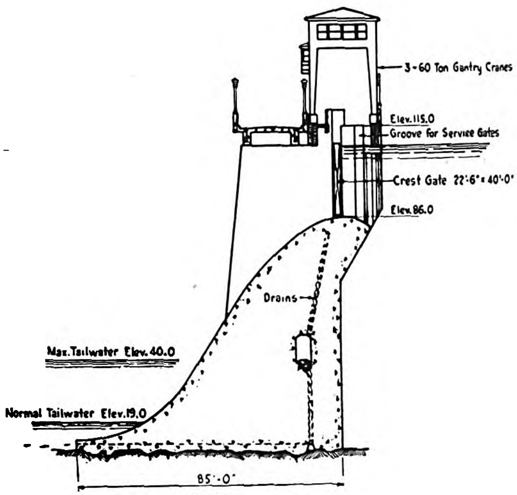
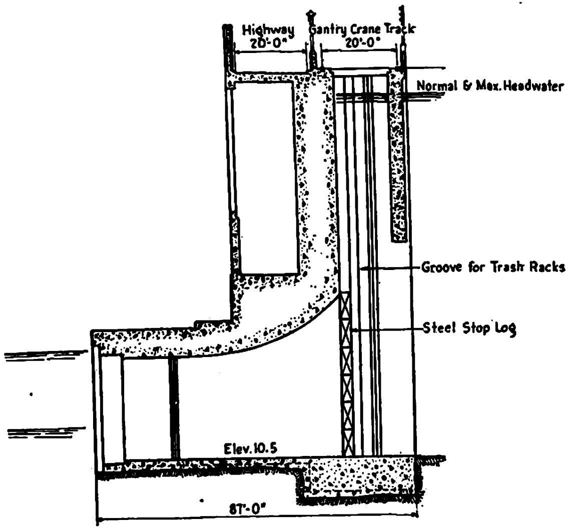

RIVER
100
Ultimate Power Sta.=950.5'
A
B
135'
3-Regulating Gates
C
50~Crest Gates=2250'
D
Abutment Section=1190'±
JONES ISL
SUSQUEHANNA
PLAN
100
50
Tail Race-West Branch
Tail Race-East Branch
ROWLAND'S ISLAND

FIGURE 7


3-60 Ton Gantry Cranes
Elev.115.0
Groove for Service Gates
Crest Gate 22'-6"×40'-0"
Elev.86.0
Drains
Max.Tailwater Elev.40.0
Normal Tailwater Elev.19.0
85'-0"

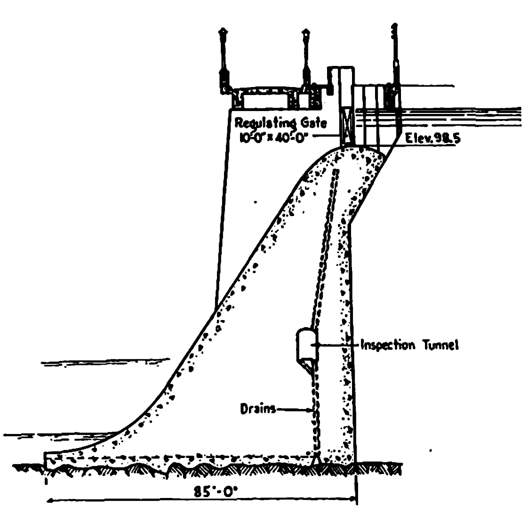
"CC"

FIGURE 10


Highway 20'-0"
Gantry Crane Track 20'-0"
Normal & Max.Headwater
Groove for Trash Racks
Steel Stop Log
Elev.10.5
87'-0"

SECTION "AA"

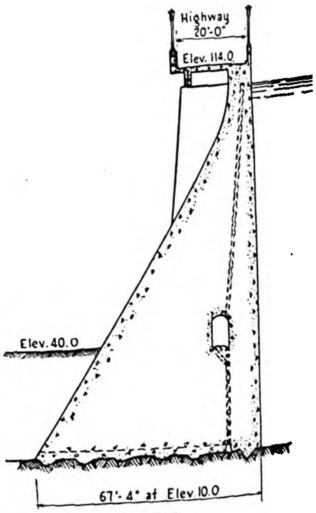
FIGURE 8


Regulating Gate 10'-0"×40'-0"
Elev.98.5
Inspection Tunnel
Drains
85'-0"

"BB"

FIGURE 9

lating gates, of which there are three. They are smaller than the crest gates and are used for fine regulation. Fig. 10 is a section at the crest gates of which there are 50 extending along the greater part of the dam, where the height of the gates is considerably greater and the height of the dam less than in the regulating section. The gantry crane is also shown. Fig. 11 is a section at the east end of the dam where the top is occupied only by the highway (Baltimore Pike) and no water spills over. It is


Highway 20'-0"
Elev. 114.0
Elev. 40.0
67'-4" at Elev 10.0

"DD"

FIGURE 11

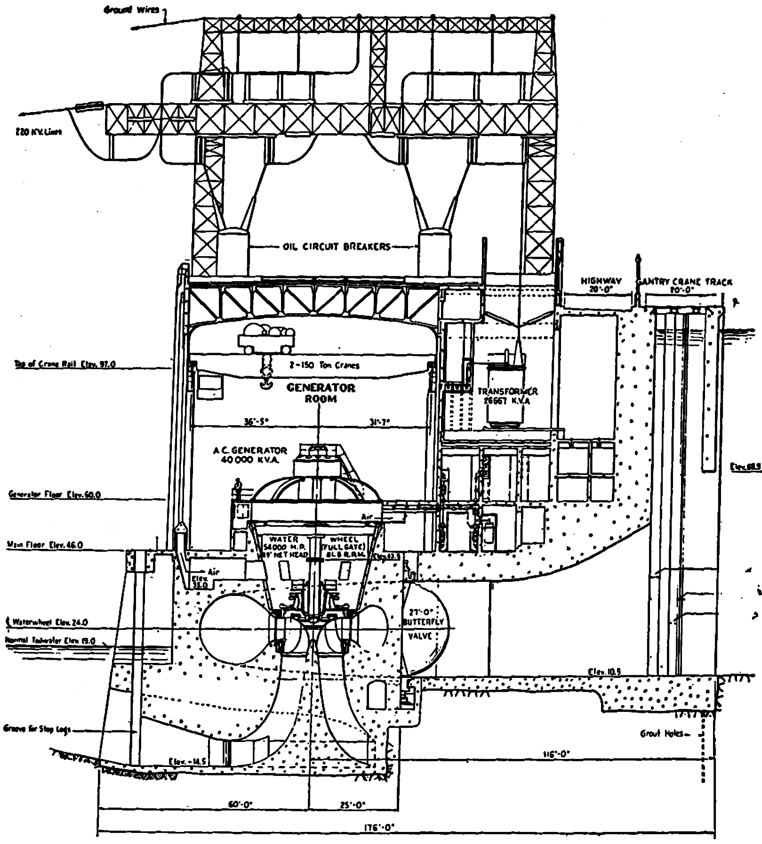

Ground wires
220 KV. Lines
OIL CIRCUIT BREAKERS
HIGHWAY 20'-0"
GANTRY CRANE TRACK 20'-0"
Top of Crane Rail Elev. 97.0
2-150 Ton Cranes
GENERATOR ROOM
TRANSFORMER 26667 K.V.A.
36'-5"
31'-7"
A.C. GENERATOR 40000 K.V.A.
Generator Floor Elev. 60.0
Main Floor Elev. 46.0
WATER WHEEL 54000 H.P. 81.8 R.P.M.
Waterwheel Elev. 24.0
Normal Tailwater Elev. 19.0
27'-0" BUTTERFLY VALVE
Elev. 10.5
Groove for Stop Logs
Grout Holes
Elev. -14.5
60'-0"
25'-0"
116'-0"
176'-0"

FIGURE 12

merely a long abutment carried from the crest gates to the east bank. The railroad runs along the right hand side.

Fig. 12 is a section of the powerhouse. You will notice the similarity of the lower right hand part with Fig. 8, the provision for the future units. The turbine is of 54,000 H. P. capacity operating at 81.8 R. P. M. Directly connected to it is a 36,000 K. W., 40,000 kv-a, 13,800 volt, 3-phase, 60-cycle generator and, directly on top of that, a 715 kv-a, 70% power factory auxiliary alternator, for the supply of the more essential auxiliaries, namely ventilating fan, governor oil pump and exciter of the unit. In other words, the power supply for operating a unit is supplied by its own alternating current generator. (There are other generators, referred to later, to take care of the lighting and general power supply of the plant.) Directly on top of this 715 kv-a. unit is its exciter. The auxiliary alternator drives a motor-driven exciter which excites the main unit. The air for the ventilating machine comes from the down-river side of the plant, passes through the main generator, then through a fan, and is finally discharged up under the highway. The 13,800 volt leads can be seen extending from the generator to an oil circuit-breaker and then up to the bus, from where it is carried on to the transformers. Each transformer is 26,667 kv-a., or 80,000 kv-a. to the bank, and steps the voltage up to 220,000. The 220,000 v. breakers on the roof and the busses are also shown. To the right of the 13,800 volt bus and under the highway are passages where the hot air from the generators is mixed with fresh air and used to heat the building in the winter time. The hot air can be discharged into the atmosphere in the summertime. The curtain wall extends down 40 feet, and it is expected will take care of any foreign matter or frazil ice getting into the wheels. The butterfly valve is

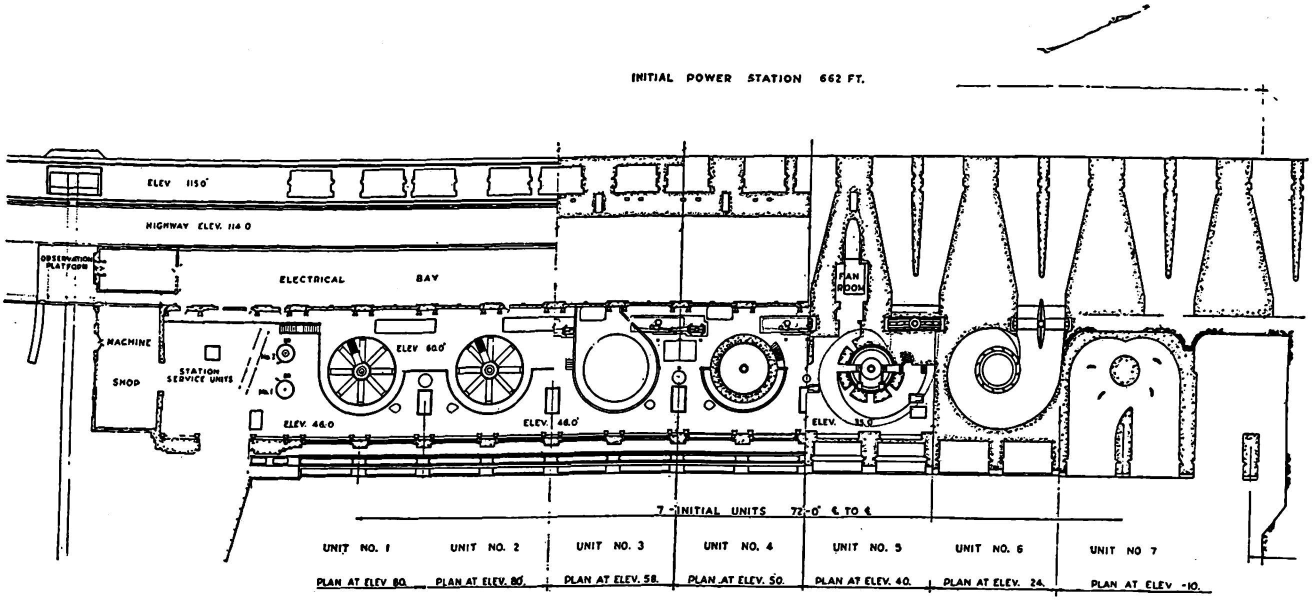

INITIAL POWER STATION 662 FT.
ELEV. 115.0'
HIGHWAY ELEV. 114.0
OBSERVATION PLATFORM
ELECTRICAL BAY
FAN ROOM
MACHINE SHOP
STATION SERVICE UNITS
ELEV. 60.0'
ELEV. 46.0
ELEV. 46.0'
ELEV. 35.0
7 - INITIAL UNITS 72'-0" ℄ TO ℄
UNIT NO. 1
UNIT NO. 2
UNIT NO. 3
UNIT NO. 4
UNIT NO. 5
UNIT NO. 6
UNIT NO. 7
PLAN AT ELEV. 80.
PLAN AT ELEV. 80.
PLAN AT ELEV. 58.
PLAN AT ELEV. 50.
PLAN AT ELEV. 40.
PLAN AT ELEV. 24.
PLAN AT ELEV. -10.

FIGURE 13

shown just to the right of the turbine. The stop logs, head gates and trash racks come in here. There are two 150 ton cranes provided in the plant.

Fig. 13 shows, at a number of different elevations, the position of the seven initial units. To the left are two smaller 1,600 kv-a. house service generators, and further left, is an assembly space in the main generator room, machine shop and office building. The electrical bay is shown directly up-stream from the turbine room.

Fig. 14, the front cover picture of this issue, is a photograph of a small model, which illustrates the cross-section of the plant.

Three of the turbines are of I. P. Morris and four of Allis-Chalmers manufacture. Three of the generators are Westinghouse and four are General Electric manufacture, but they will be very similar in appearance. Indeed, one will hardly be able to tell the difference when looking down the turbine room. The big transformers and the 13,200-volt oil circuit-breakers are General Electric. The 220 kv. oil circuit-breakers and the station service units are Westinghouse.

Fig. 15 is a single line diagram of the 13,800 and 220,000 volt equipment, and shows the seven present and four future units. If we find it advisable, the 13,800 volt bus can be made into a ring, sectionalized by oil circuit-breakers and reactors. Some of the machines and transformers can be double-bussed as shown. Units 3, 6 and 9 may be put up on the upper bus, which completes the ring, and if we choose to, eventually, operation could be such as to have that ring in four sections, with three machines on each of the three sections and two on the fourth one (this because there are only eleven units all told). We expect, however, that operation will be entirely satisfactory as planned initially and shown in the heavy line. In other words, units No. 1 and No. 2 will be connected together, similarly No. 3 and No. 4, No. 5 and No. 6, No. 7 and (when it is installed) No. 8, No. 9 and No. 10, and No. 11 will be by itself; that is, six sections, each with two 40,000 kv-a. generators, connected to an 80,000 kv-a. transformer bank, of which there will be four at first and two later. A spare single phase transformer will be provided. The tie oil circuit-breaker, between No. 4 and No. 5 units, provides for greater flexibility of operation, but that is probably the only point where such a tie will be installed.

Now to consider the 220,000 volt layout. There is a main bus to which the four transformer banks will be connected through 220,000 volt oil circuit-breakers. That is to be termed the "tie" bus. Then there is a "ring" bus carried through an oil breaker at each end in the future, but at first there will be but one of these breakers. Initially there are two 220,000 volt lines to Philadelphia, with provision for a third in the future. Each of those lines is designed to carry 250,000 kilowatts, which is the full original output of the plant.

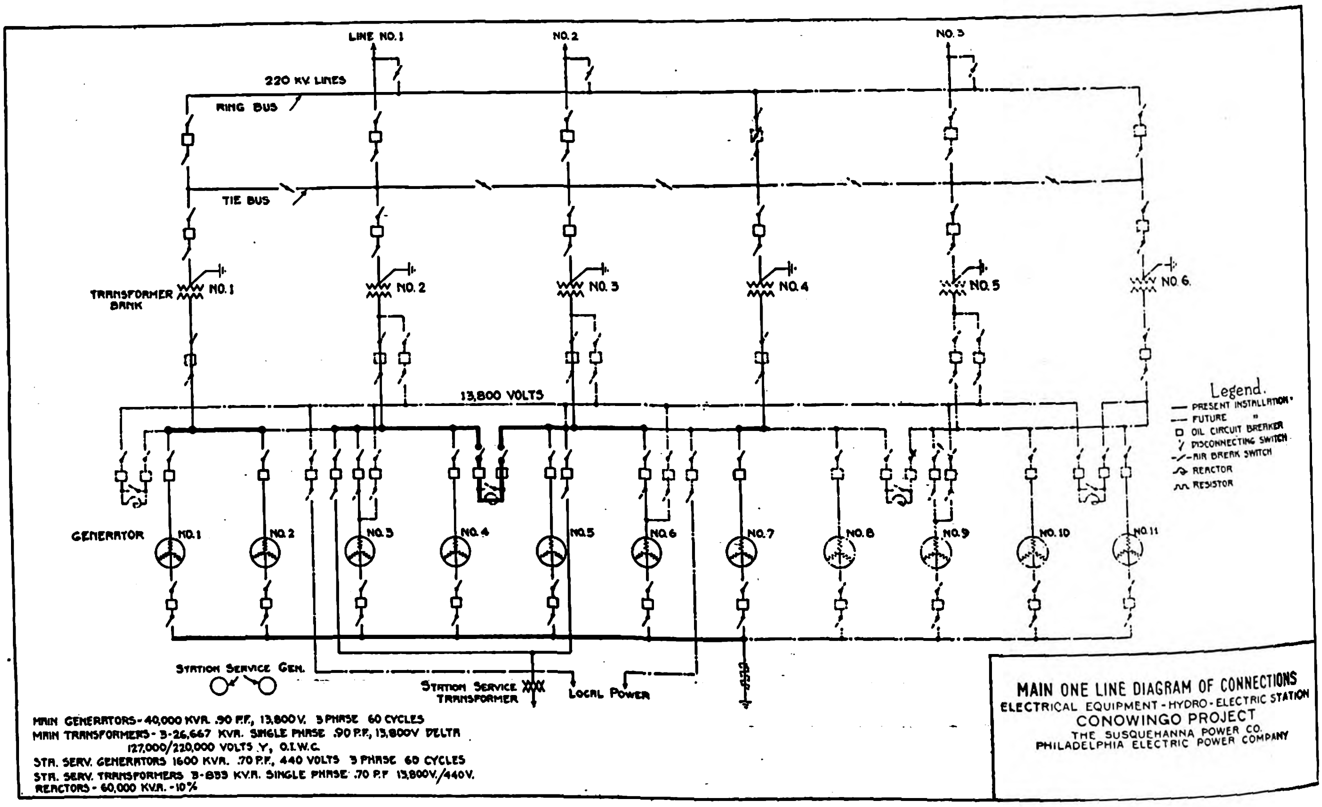

LINE NO. 1
NO. 2
NO. 3
220 KV. LINES
RING BUS
TIE BUS
TRANSFORMER BANK
NO. 1
NO. 2
NO. 3
NO. 4
NO. 5
NO. 6.
13,800 VOLTS
GENERATOR
NO. 1
NO. 2
NO. 3
NO. 4
NO. 5
NO. 6
NO. 7
NO. 8
NO. 9
NO. 10
NO. 11
STATION SERVICE GEN.
STATION SERVICE TRANSFORMER
LOCAL POWER
Legend.
PRESENT INSTALLATION
FUTURE "
OIL CIRCUIT BREAKER
DISCONNECTING SWITCH
AIR BREAK SWITCH
REACTOR
RESISTOR
MAIN GENERATORS - 40,000 KVA. .90 P.F., 13,800V. 3 PHASE 60 CYCLES
MAIN TRANSFORMERS - 3-26,667 KVA. SINGLE PHASE .90 P.F., 13,800V DELTA 127,000/220,000 VOLTS Y, O.I.W.C.
STA. SERV. GENERATORS 1600 KVA. .70 P.F., 440 VOLTS 3 PHASE 60 CYCLES
STA. SERV. TRANSFORMERS 3-833 KV.A. SINGLE PHASE .70 P.F 13,800V./440V.
REACTORS - 60,000 KV.A. - 10%
MAIN ONE LINE DIAGRAM OF CONNECTIONS
ELECTRICAL EQUIPMENT - HYDRO - ELECTRIC STATION
CONOWINGO PROJECT
THE SUSQUEHANNA POWER CO.
PHILADELPHIA ELECTRIC POWER COMPANY

FIGURE 15

In other words, with one line down, the entire output can be carried over the remaining line. Those lines connect to the "tie" bus through oil circuit-breakers. If anything happens to either of these breakers, operation over the line can be continued by means of the disconnecting switch connecting it to the "ring" bus which is connected to the "tie" bus through an oil circuit-breaker, this breaker taking the place electrically of the one that failed. The lines will be tested by means of the generators connected through a transformer bank to the particular line to be tested.

The general station auxiliary power supply is obtained from two turbine units of 1,600 kv-a., 70% power factor capacity and a 2,500 kv-a. transformer bank, feeding a 440 volt sectionalized bus. As pointed out above, the main generator auxiliaries (fan, exciter and governor oil pump) are supplied from a shaft-end alternator. The bus to which this alternator is connected has an emergency supply from the main 440-volt bus.

The general motors throughout the plant have two supplies, each from different sections of the bus. The lighting is 110-220 volt from transformers stepping down from 440 volts. There is one spare exciter going in at present with provision for another should we decide to install it in the future; they are supplied from the general service bus. The operating village service and series lighting for the top of the dam come from transformers also connected to this 440-volt bus.

The 220,000 v. structure on the roof is shown in figure 16. A change in design has placed all the 220,000 v. oil circuit-breakers in a single line instead of two as shown.

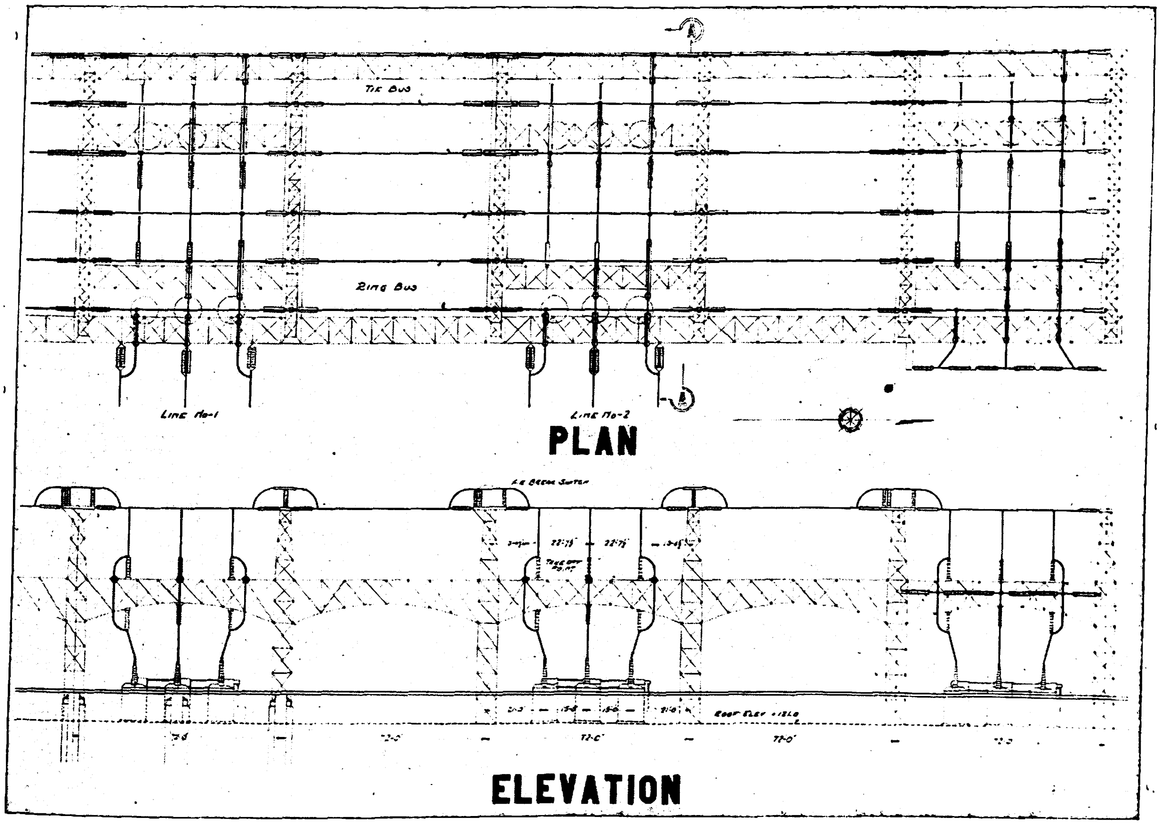


FIGURE 16

DISCUSSION

CHAIRMAN: Mr. Moody, will you tell us something additional about the turbine units?

LEWIS F. MOODY: The turbines are 54,000 H. P. capacity each. The head is rather variable, but the normal head for which they are designed is 89 feet. The turbines are of the conventional, so-called, "Francis" type. The specific speed, a term we deal with, is of a normal value, because the head is neither excessively high nor extremely low. This type of turbine can give very high efficiency. One of the unusual features of the plant was the use of a butterfly valve at the entrance to the turbine. Instead of depending on lift gates at the entrance, the water will be closed off by these large circular butterfly valves, immediately at the entrance to the turbine casings. That resulted in some little economy of construction, and also gave a very quick means of shutting off the water after the turbine is closed down. The plant will be operated during a considerable part of the year for only a limited number of hours per day, and during the remainder of that time, it is necessary to shut off all leakage. If the turbines were allowed to stand with only the wheel gates closed, there would be some little leakage, small, to be sure, but considerable in the aggregate over several hours of the day; and although the leakage amounts only to a very small percentage of the quantity normally passing through the turbines, you can well see that this loss of water each day would amount to a material percentage of the entire consumption of the plant. For that reason it was desired to have very tight gates which could be closed off quickly and again opened quickly, so that the plant could be put in operation very promptly as soon as the load demand requires it.

One of the interesting features of this design is that originated by Mr. Frank H. Rogers, namely, a rubber seal ring around the butterfly valve. There is a rubber hose in four sections imbedded in the casing around the valve disc and after the disc is closed off normal to the pipe, water pressure is put into this hose, expanding it against the edge of the disc and providing very tight closure. This is the first time this method has ever been used and at Conowingo is being applied to the largest valves, I believe, that have ever been built. These valves are 27 feet in diameter across the disc.

The turbine has a speed ring, as we call it though it is a very poor term, because it is the one thing about the turbine that does not move, surrounding the movable gates, with vanes extending vertically to carry all the superimposed weight down to the concrete underneath the turbine. Thus the load is carried around the draft tube and at the bottom of the draft tube is a ring of very heavy cast steel vanes acting as columns to take the weight down to the rock underneath. That makes a very stable structure and a very economical one. In addition there are piers across the draft tube discharge passage, carrying the down stream portion of the powerhouse. The revolving weight, of course, is carried on the thrust bearing, mounted on top of the generator so that part of the unit is supported from above. These bearings are Kingsbury in the Westinghouse and spring in the General Electric. There is not much difference between the two.

In event of the butterfly valve failing there is provision for an emergency head gate which can be dropped by the gantry crane in front of any one unit to unwater the butterfly valve.

The efficiency of the wheels will be quite high to about half load. Then begins a progressive fall off to the small loads. There will be very little demand, I should think, in ordinary operation to run these units at low load; probably most of the operation will be very close to the best efficiency point; with all this storage back of the powerhouse it ought to be possible to do that.

The units are designed to be safe for the highest possible runaway speed, under the highest head to which they can be subjected. It runs up to about double speed, and they are guaranteed to operate that way without any material approaching the elastic limit.

MR. FUNK: A foot draw-down on the pond gives about 700,000 kilowatt hours, but after the head is reduced 10 feet, the efficiency goes off pretty badly.

I do not know whether it was Mr. Moody's modesty that prevented him from saying it or not, but making these butterfly valves 27 feet in diameter watertight, presented quite a problem. You may not realize it, but when you have a hole in concrete 27 feet in diameter, the change in the shape of that orifice, with the changing waterhead and with the changing load conditions between unloaded and loaded, with the tunnel full of water, and with the head gate shut off so the tunnel is empty, means considerable distortion from round. Now any mechanical fit that would be sufficiently tight under one condition would have to be a rather intricate mechanism if it was going to be tight under another condition. A lapping gate, or one that came against a side seat, would be open to the objection that fine material of any sort—and the river will be full of it—which the screens will not stop, will get in against that seat, and with the heavy pressure in closing against it, would damage the seat, so that, after a few closings and openings, the seat would permit quite a perceptible amount of leakage. As Mr. Moody explained, this problem was solved very efficiently by allowing quite a clearance between the seat and the disc. Then that space is closed by the rubber hose which will fit the surface of the disc tightly, closing the annular opening between the disc and the housing in spite of any distortion. To test the idea, the I. P. Morris Corporation made a small section of gate and housing and put rubber hose in it and you would be surprised how it held against a good heavy water pressure with a very small difference between the pressure in the hose and the pressure of the water against the valve. It seems that all you have to do is to get a slight excess pressure in the hose over the head on the gate. Just as soon as you let the water pressure in your hose get down to equal to or less than the pressure on the gate, the water squirts through. The section that was built was full-sized and demonstrated conclusively that this device in operation is going to be very tight indeed. The hose's 3½" O. D. and ½" thick.

The gates are balanced and may be opened against full head pressure. There is a vertical shaft in the center of the gate and the water on one side of this counterbalances that on the other so that there is no pressure opposing the opening. Of course, there is full head pressure against the trunions, the top and bottom thrust bearings, and the whole weight is supported on the step at the bottom.

The time cycle figures indicate that it will be possible to get one of these units from rest onto the line in about a minute; a 36,000 kilowatt machine.

The first unit is expected to be put on full load test by the first of March, 1928, if everything works out all right. That will be just a little less than two years from the time the houses for the men on the job were started.

The operating personnel of the plant will include about forty-four, including the maintenance men; a contrast with a plant of equivalent size in steam which would probably require something like 225.

Per K. W. capacity the cost of construction, as compared with a modern steam plant, is somewhere about twice—that is, including the transmission lines, and delivery to the city at the same voltages as from the steam plant. You mustn't compare the capital cost of hydro-electric plants with that of steam plants, because the operating cost of a steam plant is incomparably greater than that of a hydro-electric plant. The only way to make comparisons is to consider what you get out of it, and that is different for every hydro-electric development.

This plant will not be tied in with McCall's Ferry, but the operation of this plant will be similar to that of McCall's Ferry, and one of the things that helped this plant, in so far as pond elevation is concerned, is that it runs practically the same cycle as McCall's Ferry, and, therefore, when we allow our pond to fill up during a shut-down period, they are allowing their pond to fill, too; are not shooting the water down too fast, so we have a longer period to let our pond fill. When our water is being used, they are letting it run into their tail race and so into our pond. That means that peak operation can be obtained without proportional draw-down on our pond.

MR. HENTZ: The relay scheme for automatic protection is a rather involved one. In the first place, the generators are protected by differential relays, which is the general practice in our system and practically all other systems. The prime purpose of them is, of course, in case of failure, to take the generators off the lines to prevent burning of the iron. The protection of the 220,000 v. lines is by means of impedance relays. The protection of the transformer bank would also be by differential relay—both the big bank and the small bank.

The transformer bank and the generators will all clear if there is a short circuit on the 13,200 v. bus system.

We have a motor-driven exciter for each main unit. There are seven main units and eight motor-driven exciters. Seven of these are associated, one each with each main unit and the power to drive the motor comes from the auxiliary generator mounted on the same shaft as the main unit. Now should any one of these exciters break down, the eighth exciter can be electrically connected in its place. The motor of this eighth or spare exciter receives its power from the general station light and power supply buses.

Motor driven exciters are used primarily because we wanted very quick response excitation, which can be gotten by high rotation speed. The speed of the main units is only 81.8 R. P. M., too slow for the exciters.

FRANK H. ROGERS, I. P. Morris Corporation: It seems to me Mr. Moody covered the subject of the butterfly valve pretty thoroughly, but I might say that, when this proposition was first put up to us by the engineers telling us they had in mind limiting the leakage of these valves to a definite figure of 5 cubic feet a second, and we then made some calculations to get some idea of how close the clearance would have to be between the disc and the housing under the head of about 81 feet on the valve, as I recall it, it figured out at about 1/100th of an inch. As Mr. Funk explained very clearly, with a housing of this diameter of 27 feet, we were very sure it was impossible to attain a mechanical clearance of anythink like 1/100th of an inch between the moving disc and the stationary housing because of the change in shape under different loads, so we decided, to play safe, that the clearance would have to be 3/16", which would permit a leakage extremely large in comparison with this desired leakage of not more than 5 cubic feet per second. We started figuring on what could act as a seal extending out and closing an opening of at least 3/16" all around, and the result of those studies was the selection of rubber. In making the experiment on the molds, we found out that this 3½" tube which is about ½" thick, could be extended out through a slot, about 1" wide (I think it was), if nothing were in the way, about ¾", with the pressure of about 40 lbs, so that, as we placed the disc only 3/16" away, it gave the effect of an extremely hard seal. We also made a rather interesting experiment as to the effect of small particles getting between the disc and the rubber tube, by putting in a lot of nails and wire across the disc and then expanding the rubber on top of them and we found that the rubber would embed these nails and, even with them in, scarcely a drop of water would come through. The rubber manufacturers, when we took the question up with them, said we couldn't have selected a better location for rubber. Apparently the most important point of all is the darkness, as, they say, if rubber is kept in the dark its life will be indefinite. Add to that the water presence and we have the two factors tending toward long life. So I think the rubber people will check up with Mr. Funk when he said the life will probably be about fifty years.

The Business Situation

The following excerpts from the latest monthly letters of the Guarantee Trust Company, New York City, and the Cleveland Trust Company, Cleveland, Ohio, set forth opinions as to the present business situation which are based on long experience in watching the results of conditions and their influence on the future of business.

GUARANTY TRUST COMPANY OF NEW YORK

BUSINESS developments of recent weeks have tended to indicate a divergence of trend as between industrial output and trade volumes. As regards the former, it appears that the autumn revival has been distinctly less pronounced than is usual at this season. In some lines there has been little or no expansion since midsummer, and in general it may be said that operations are on a measurably lower plane than a year ago. This tendency, however, is by no means uniform. With due allowance for the effects of curtailment in automobile manufacture, which is due partly, if not mainly, to special and temporary conditions, it may be maintained that the trend in other industries is not far out of line with the usual seasonal movement.

Effects of Decline in Motor-Car Output

The chief tangible evidence of tardy recovery is found in the iron and steel industry, where operations have remained almost unchanged for four months. This situation is certainly due in part to reduced demand for steel on the part of motor car producers. But, in addition to steel, it must be remembered that the automotive industry has become one of the largest consumers of a number of other metals, as well as hardwood lumber, plate glass, upholstery leather, rubber and many other products. The resumption of normal conditions in the automobile trade may be followed by a large volume of deferred buying, which would stimulate activity in nearly all branches of business.

Recent trade reports indicate that merchandise continues to move readily through the channels of distribution. It is true that railway freight loadings are below last year's unprecedented totals; but they are larger than during the summer, and the decline from the level of a year ago is largly due to reduced shipments of coal and coke resulting from the strike.

Outlook for Continued Prosperity

In the face of favorable trade reports, combined with high levels of employment and wages and very low money rates, there is little ground for anticipating any prolonged or violent decline in general business activity. The outlook is rather for the continuance of trade and industry at a rate comparable with that of the early part of this year. While it is not likely that many industrial records will be broken during the next few months, neither is it at all probable that the substantial and widely diffused prosperity of recent years is about to be seriously curtailed.

Favorable Position of Agriculture

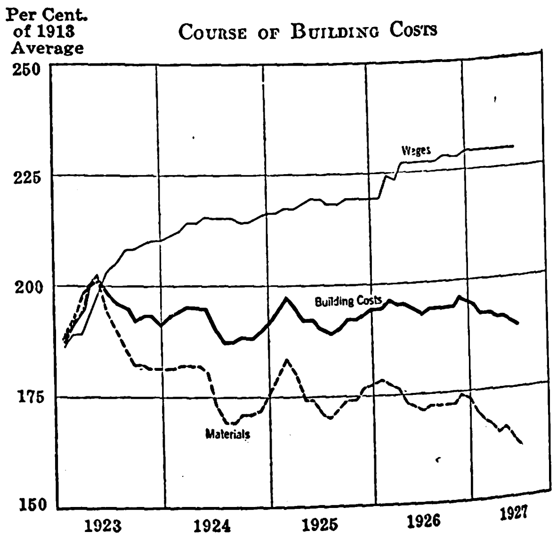
One of the strongest favorable influences in the immediate outlook is the great improvement in the position of agriculture. Aggregate farm returns far above those of last year are now assured. In some cases the enhancement of earnings is due to larger yields and in others to higher prices, but almost without exception the producers of the major crops will have larger receipts this season than have been the rule in recent years.

Strong Credit Situation

Another factor that will tend to prevent any marked recession in business is the strength of the credit situation. With the Federal Reserve ratio at 75 per cent, and with rediscounting at the Federal Reserve banks at a very low level, it is evident that there is a vast amount of reserve credit at the disposal of the business and financial community. Although loans and discounts, as well as investments, of the member banks reporting weekly to the Federal Reserve Board are at peak figures, rediscounting has decreased since the beginning of this month, and is now smaller than it was during the summer.

Building Values Rising Despite Lower Costs

An interesting phenomenon of the present building situation is the increase in the average value per unit of floor area of contract awards despite the steady decline of building costs. The square-foot value of floor area of building contract awards in 36 states in 1923, based on figures of the F. W. Dodge Corpora-



Courtesy of Guaranty Trust Co.

tion, averaged $5.88, which compares with $7.57 in the first nine months of 1927.

Building costs since 1923, as measured by the index of the Federal Reserve Bank of New York, have not advanced with the increase of building values, the index of average costs for September standing about 3 per cent below the level of 1923. As may be observed in the chart showing comparative building costs, the trends of wages and materials have been in opposite directions. On the whole, however, the respective increase and decrease of wages and materials have practically offset one another and the net change in total building costs is relatively slight. This rise of wages and fall in the cost of materials correspond with the general trend of these items throughout the country and are illustrative of the increased efficiency of industry and larger per-man output.

THE CLEVELAND TRUST CO.

SHORTAGES are in the making in iron and steel, and automobiles, and railroad equipment. In these important lines production has fallen below normal consumption, and there are no large stocks on hand from which consumption can draw. This means that before very long production must start up again, for buying demand is surely accumulating.

This condition is an unusual one, for in the past the downward swings of the more important items of industrial production have usually followed periods of inventory accumulation induced by advancing prices. During this year, on the contrary, the trend of wholesale prices has until recently been a declining one for most commodities, and notably so for iron and steel products. As a result there has been but little accumulation of speculative inventories, and so the current low rates of output mean that shortages are developing rather than that surpluses are being worked down.

The conclusion that industrial activity is more likely to increase again in the not far distant future rather than to go into a protracted decline is reinforced by the fact that the new bond issues in October reached record high totals. It is true that unusually large amounts of these were for foreign account, but even so the new domestic industrial and utility issues were so great as to insure very large volumes of expenditure for construction and equipment during the months that lie ahead.

New construction continues to go forward in large volume, although building is slow in a good many individual localities. The highest levels of activity appear to have been reached and passed some months ago, but the important fact is that building construction has not reached a peak of volume and apparently is not going to, for a peak implies a steep decline on the other side. It worked upward on a long sustained advance from 1920 to 1925, and since then it has been on a sort of a high plateau which lately has shown some indications of slanting down a little. There is not, however, any indication that new building is going to slump off, and the prospects are rather that it will continue in truly large volume as long as funds for new construction can be obtained on easy terms and at low rates.

The general situation may be summarized by noting that business is slowing down under conditions that make it appear much more probable that it will in the not far distant future increase its activity again than that it is likely to continue into a protracted decline. Industrial production in some important lines has slowed down, but consumption continues on so great a scale that it promises to require increased output before long in view of the fact that there are no important stocks of goods to be worked off. The crops are better than it appeared possible a few months ago that they could be. Funds are pressing for investment, and they are finding it largely in expansions of constructive enterprise. Building holds up in volume remarkably well. Export trade is large.

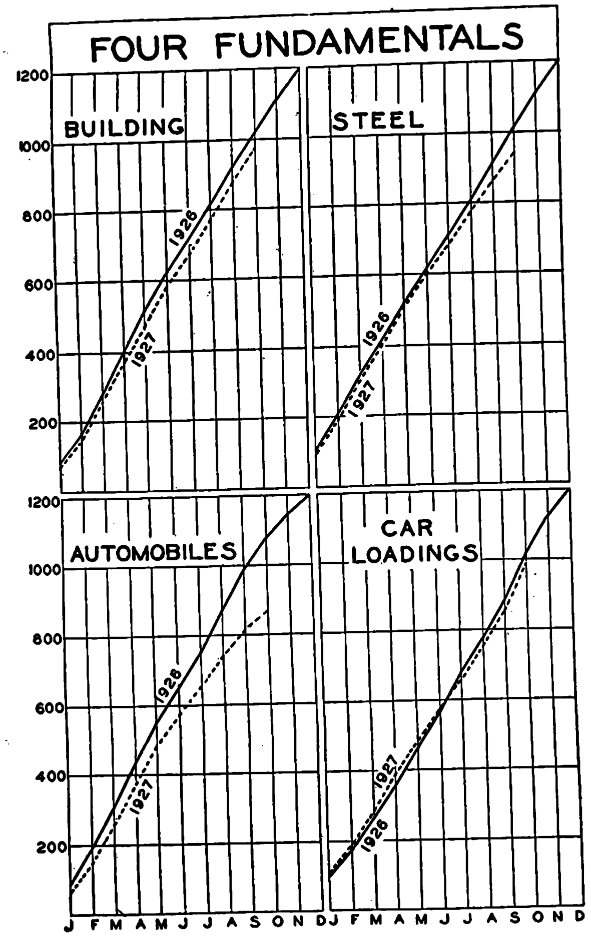
The fundamentally important fact behind all these elements of the general situation is that our credit supply is so vast and so flexibly available, and the Federal Reserve System operates so efficiently and smoothly, that we no longer have to fear a recurrence of the wide swings from prosperity to depression that formerly afflicted business in this country. Our banks are stronger than ever before. Our industrial corporations have reserves in cash and securities far in excess of those they held in former years. The generally healthy condition of our credit structure extends down even to conditions in the field of installment financing, where the dangerous developments that were apprehended a year or two ago have not come into being.

Industrial profits are going to be somewhat smaller in the aggregate this year than they were in 1926, and the production records of the year will be rather less in a number of important lines than they were last year. These facts illustrate the important truth that we cannot expect always to have an unbroken succession of years of record-breaking prosperity. It is doubtful if they signify more than that.

1927 Falls Below

The revival of business that regularly comes in the autumn months is falling below expectations, and in general it is now clear that the records of industrial activity for 1927 are going to be in most cases somewhat reduced below the figures of 1926. This means that there has taken place a real, although not drastic, decline in general business activity this year, for it is normal in this rapidly growing country for the production and consumption of most important groups of commodities to increase from one year to the next.

The diagram illustrates the extent of the declines



Courtesy of Cleveland Trust Co.

so far in four great industries, from the records of 1926 to those of 1927. In the upper left hand corner of the diagram the solid black line illustrates the cumulative record of the square feet of new building construction in 36 states last year as reported by the F. W. Dodge Company. Each space from left to right represents one month, as indicated by the letters at the foot of the diagram, and the amount of new building contracted for in the average month is taken as being equal to 100, so that by the end of the year the black line has risen to 1200.

The record of 1927 is represented in a similar way, but here also the average monthly figure for 1926 is still taken as equal to 100. It is noteworthy that the dotted line for 1927 has consistently lagged below the solid one for 1926, and it is clear that there is no probability that it will reach 1200 by the end of this year. The probabilities are that it will fall below by something like three per cent of last year's final record.

The record of the production of steel ingots makes a somewhat better showing, and up to the middle of the year it was almost as good as that of 1926. However, it is now failing to keep up with last year's records, and it is probable that the final figures will not make as good a comparative showing as those of building. Still more serious declines are to be noted in the section of the diagram illustrating the output of passenger automobiles and trucks in this country. It now seems not unlikely that the production figures of the year may fall below those of last year by something like 15 per cent, and this sharp decline will be largely accounted for by the long shut-down of the Ford plants.

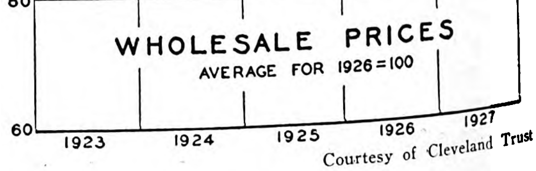
The record of car loadings of freight on the railroads is a better one, and up to the middle of the year it was actually running ahead of that of last year. The final record of the year will undoubtedly be lower than that of 1926, but by no great margin. A real slowing down of productive industry has been taking place. It has not been very serious, but it has been pretty general. It now seems probable that a similar diagram drawn a year from now would show the lines for 1928 running above those for 1927.

Wholesale Prices

A new index number for wholesale prices has been compiled by the Bureau of Labor Statistics of the United States Department of Labor. It reflects the price changes in 550 different classes of commodities, and is probably the best and most comprehensive price index compiled by any nation. Instead of going back to a pre-war basis, and recording price changes by taking the average of prices in 1913 as being equal to 100, the new index recognizes the fact that we are in a new economic era and issues its monthly findings in terms of the average prices of 1926 being equal to 100.

The new index has been carried back through 1923, and will shortly be computed to a still earlier year. The diagram shows the new data for the prices of farm products and industrial products each month during the five year period since the beginnnig of 1923. It is noteworthy that changes in the prices of farm products tend to be greater than in those for industrial goods, to start their major swings somewhat earlier, and usually to move in the same direction.

Until recently it has been generally held by students of applied economics that periods of good business were always, or almost always, periods of rising commodity prices, and that at times when the price



Courtesy of Cleveland Trust Co.

trend declined business slowed down. The period of the past three years has been a marked exception to the old and well-established rule. It has been a period of great prosperity, for during it our national wealth has increased at a rate probably never before equalled by any nation in history. Nevertheless, it has been a period of declining prices. In the past few months general business has been slowing down, but the price trend has reversed itself, and has been rising.

It is as yet too soon to tell whether the present forward movement of prices is a merely temporary fluctuation, or whether it is to continue long enough to bring about important changes in the conditions of general business. If it should continue for a considerable time, and include most classes of goods, it would tend to lessen the extreme keenness of competition that has of late characterized most lines of industry, and to benefit promptly firms producing raw materials and those making goods requiring small amounts of elaboration by skilled labor.

In the long run the old rule that general business prospers when commodity prices rise, and slows down when they decline, may still be expected to hold good. Nevertheless, it has been impressively demonstrated that there may be important exceptions to it when credit supplies are as ample as they have recently been with us. The present prospects are that we shall continue to have in this country ample supplies of credit available at easy rates, and that business will not decline to depression levels as long as that condition continues, irrespective of whether the general price trend is an advancing or a declining one.

Iron and Steel

Failure of the iron and steel industry to improve materially during October may be taken as an indication that any marked gain is unlikely during the remainder of this year. In two directions—pipe lines for the Southwest and railroad track material for 1928 delivery—the outlook is materially brighter, but the run of orders that mean immediate tonnage for the mills is restricted to a volume that keeps mill operations at between 65 and 68 per cent of capacity. The daily average output of steel ingots increased by about 1.6 per cent in October, compared with the September rate, but it was nearly 20 per cent below the rate of October, 1926.

At this time the major outlets for iron and steel products afford no basis for expecting a substantial increase in demand over the remainder of this quarter. Railroad commitments for track material equal, and in some instances exceed, 1927 requirements, but the great bulk of this tonnage will not be rolled until the first half of the new year. Freight car buying is so slow it is doubtful whether last year's meager total of 60,575 cars can be equalled. In October orders for new freight cars dropped to the low level of about 560.

Consumers continue to dominate the price situation. Average iron and steel prices are now 7 per cent below the level of 12 months ago. Current quotations on the average are at the lowest levels reached since 1916, with the exception of the 1921 depression. At $17 a ton basic valley pig iron has fallen through the 1921 bottom levels to the lowest point touched since 1915. Low prices together with reduced volumes caused profits of many iron and steel companies to recede sharply in the third quarter.

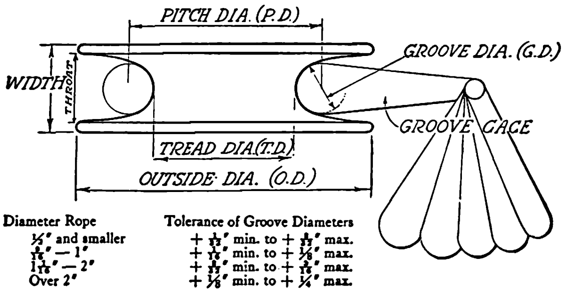
Pig iron production in October continued the decline in progress since last April. At 90,652 gross tons, the daily rate was the lowest in 26 months. Six less stacks were active at the end of October than at the close of September, the 175 in blast representing 48.4 per cent of the 361 serviceable furnaces in the country.

Do the Sheaves Fit the Rope?

There is perhaps no single element that can be more detrimental to wire rope than an improperly fitted sheave. When installing a new rope, therefore, it is economy to gauge both the rope and the grooves of all sheaves and drums.

One of the simplest and most accurate methods for gauging sheave treads is through the use of a groove gauge as indicated by the accompanying illustration. If this device is used with care, and if the tolerances given as stated (which have been worked out in accordance with long experience) are strictly adhered to, there may be reason to expect longer and more satisfactory rope service.

Proper Groove Diameters for Various Size Ropes



Diameter Rope	Tolerance of Groove Diameters
½" and smaller	+ 1/32" min. to + 3/32" max.
9/16"—1"	+ 1/16" min. to + 1/8" max.
1 1/16"—2"	+ 3/32" min. to + 3/16" max.
Over 2"	+ 1/8" min. to + 1/4" max.

NEW BOOKS

BOOK REVIEWS

Orders for any books, domestic or foreign, will be filled promptly by shipment direct from publisher. We receive orders for all classes of books — **fiction, biographical, technical, historical, etc.** We solicit your business.

ENGINEERS AND ENGINEERING
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Steam and Gas Turbines—By A. Stodola, Professor at the Polytechnikum, Zurich; translated from the Sixth German Edition by Louis C. Loewenstein, Consulting Engineer, General Electric Company. Two volumes, 7x10, 1356 pages, 1105 illustrations, 12 charts in cover pockets. $15.00.

A detailed translation of Dr. A. Stodola's great work covering completely the theoretical aspects of steam and gas turbines; illustrating and describing the designs and actual construction of all types of steam turbines; and giving the necessary experimental data for determining the actual construction of these engines. The entire translation is in English units, and all formulae and experimental results are given in these units.

Business Cycles, the Problem and Its Setting — By Wesley C. Mitchell, Director of Research in the National Bureau of Economic Research. 489 pages, 6x9. Cloth, $6.50.

For those that have read exposition after exposition of theories concerning the causes and origin of the socalled "business cycle" and whose ideas on the subject have become more and more in a state of flux as their reading continued, this book should serve as a start toward a solid foundation from which the whole field may be viewed in something like correct perspective. As the sub-title indicates, the book is devoted to making clear what and where the problem really is; a second volume on "The Rhythm of Business Activity," which is promised by the author, will, no doubt, offer methods of attack and control.

Memorandum—World's Mechanical Engineering Industry—Prepared by Dr. Karl Lange, for the Verein Deutscher Maschinenbau-Anstalten, with Observations on Same by the British Engineering Association, and by three French and one Italian Engineering Association, being Volume I of the Mechanical Engineering Division of the Documentation of the International Economic Conference of the Economic and Financial Section of the League of Nations. 193 pages; 8x10½. Paper. $1.50.

Monograph on the Economic Situation of the British Engineering Industry—Prepared by the British Engineers' Association, and note on the Austrian Mechanical Engineering Industry, submitted by the Verband der Oesterreichischen Maschinenindustrie, being Volume II of the above. 92 pages; 8x10½. $0.75.

These have been issued as part of the documentation of the International Economic Conference, which began its sessions at Geneva on May 4. The document was prepared by the Economic and Financial Section of the League of Nations from information furnished to it by governments, by members of the Preparatory Committee for the Conference and by industrial organizations, which prepared memoranda at the request of members of the committee.

Concrete Building Construction—By Theodore Crane, C. E. Edited by the late Thomas Nolan, M.S., A. M., Editor Kidder's "Architects' and Builders' Handbook." 689 pages; 6x9; illustrated. Flexible binding. $6.00.

This book is designed particularly for construction men—designers, engineers, architects, contractors. It covers every detail in practical design from the most elementary stress relationships, step by step, up to and including problems in continuous frames. Estimating, cost accounting, office procedure, field superintendence, are all treated in a simple and direct way by an engineer with many years of practical experience.

Industrial Safety Organization—By Lewis A. DeBlois. Director, Safety Engineering Division, National Bureau of Casualty and Surety Underwriters, Past President, National Safety Council, formerly Manager, Safety and Compensation Division, E. I. duPont de Nemours and Company. 330 pages; 6x9; 22 illustrations. $4.00.

This book illustrates convincingly the economic value of industrial accident prevention, throwing the striking reductions and relatively large savings made by prominent industrial plants and corporations into sharp contrast with the record of industry as a whole. It describes the remarkable "No-Accident Records" which are proving that no industrial accident is unavoidable. These are hard dollars-and-cents facts which will impress the business manager. "Industrial Safety Organization" shows why a safety organization is necessary and what its relation to the existing operating organization should be. It brings out clearly the part played by executive leadership and responsibility.

Profit Sharing and Stock Ownership for Employees—By Gorton James, Henry S. Dennison, Edwin F. Gray, Henry P. Kendall, Arthur W. Burritt. 385 pages. Price $4.00.

This book is an exhaustive, businesslike description of the growing movement among corporations to share profits with employees. It describes, analyzes and evaluates the numerous profit-sharing and stock-ownership plans which corporations have introduced in the last ten years.

Any company which wants to know what to do and how to do it in the way of introducing some method of sharing its prosperity with employees, will find here sample plans, helpful suggestions and detailed hints, and every company now using some method of extra payment along these lines can check its experience against that of all the rest of the companies working along similar lines.

Hydro-Electric Handbook—By William P. Creager and Joel D. Justin, and a staff of nine specialists. 897 pages; 494 illustrations. Flexible binding. $8.

The book is a complete working treatise on current practice. It represents the work of a staff of 11 well-known specialists. It contains much data hereto unavailable in any book. The book is unusually replete with valuable diagrams, tables, charts and other illustrations.

In a field where practice changes rapidly this book is the last word on latest developments and approved modern methods. Every phase of the subject is covered from the time the project is a dream in the mind of the promoter to the operation of the completed plant.

The Ancient Greeks and the Evolution of Standards in Business — By George M. Calhoun. 103 pages, 4½x7. Cloth, $1.00.

This is one of the Weinstock Lectures on the morals of trade delivered at the University of California. It brings out very clearly and brilliantly, the part played by Greek civilization in setting up a standard of economic freedom in commercial intercourse to which the whole western business world is still indebted. It is convincing that we must look to that wonderful civilization for not only our inspiration in art and literature, but also for the principles on which modern trade is based, as we have been accustomed to do.

Electrical Engineering—By T. F. Wall of the Department of Applied Science, University of Sheffield, England. 491 pages, 463 figures. $5.25.

"The purpose of this book is to meet the demand for a complete survey in one volume of the principles of electrical engineering, and it is intended for students in Universities and the advanced classes of Technical Schools, and also as a reference book for electrical engineers in practice." The above sentence copied from a statement by the publishers describes the book very well. The author includes more of the underlying physical theory than is usual in an American text book, but this is not at all a waste of space, as it makes this groundwork immediately available for reference and in the same terminology, even if the subject matter is considered to have been covered by previous or accompanying Physics courses.

With this starting point, the theory of Electrical Engineering is developed in a very complete and thorough manner. Practice is not carried to the point where any distinction would be made between American and British customs. The book is, therefore, exactly as useful in this country as in England. Although there are many books on the subject, very few of them are as complete as this.—C. W. B.

Transmission Circuits for Telephonic Communication—By K. S. Johnson of the Technical Staff, Bell Telephone Laboratories, Inc. 334 pages, 143 figures. $5.00.

This book will have little interest or value to the engineering public in general, but to those interested in communication problems it should be of extremely great value. Starting with the general fundamentals of electrical theory, the author develops the theory of the various types of circuits peculiar to telephone practice, such as filters, repeaters and superimposed circuits. This is done in general by the methods of vector algebra.

Several lists of formulae are given in a group of appendices which are noticeable for their completeness, some of which will be found useful in other engineering fields. These lists include miscellaneous mathematical formulae complex quantities, hyperbolic functions, etc.—C. W. B.

The Mathematics of Engineering—By Ralph E. Root, Professor of Mathematics and Mechanics, Post Graduate School, U. S. Naval Academy. 550 pages, 115 line cuts. $7.50.

This book was written to fill the need for a general text book on engineering mathematics to be used in the author's classes in the Post Graduate School of the Naval Academy. It presupposes a knowledge of the usual mathematics of an undergraduate engineering course, but includes a brief but thorough review of certain parts such as the solution of equations, analytical geometry and elementary calculus. With these as fundamentals, the author develops the higher branches such as harmonic analysis, least squares, differential equations, complex functions, etc., in such a way as to make them available for engineering applications. He does this more from the standpoint of the engineer than of the mathematician, and has produced a book which should prove very satisfactory, not only in class study but also to those engineers who may need an advanced reference book. There is one omission (and this is probably intentional) of a topic which might be expected in such a book. No review of trigonometric topics, or of their application to navigation and astronomy is included.—C. W. B.

Wiring Materials and Devices

Arrangements have now been made for the development and revision of specifications and standards for electrical devices and materials with relation to fire and casualty hazards, under the procedure of the American Engineering Standards Committee and the sponsorship of the Underwriters' Laboratories. The index of the well known "List of Inspected Electrical Appliances of the Underwriters' Laboratories" may be taken as a description of the classes of appliances intended to be covered in the undertaking.

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THE NATIONAL, STATE, AND LOCAL TUBERCULOSIS ASSOCIATIONS OF THE UNITED STATES

ENGINEERS & ENGINEERING

DECEMBER, 1927

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No. 12

Safety in Aviation

A symposium sponsored by the Engineers Club of Philadelphia, The Aero Club of Pennsylvania, and the American Society of Mechanical Engineers (Philadelphia Section), held on the afternoon and evening of Tuesday, October 18, 1927.

AFTERNOON SESSION

How It Happened

COL. J. H. M'. ANDREWS, Presiding

FIRST and foremost, gentlemen, I want to express the gratification of the Engineers Club, the Aero Club of Pennsylvania and the American Society of Mechanical Engineers for the fact that you gentlemen have taken time from your busy lives to come here and join with us in this meeting today. We appreciate it very much, and we hope that all of us will enjoy no inconsiderable gain from this interesting contact.

It is a habit of us Americans when we become excessively interested in anything, to speak of it as having developed a "consciousness," and so this year particularly the American public have been developing an "air-consciousness." The great things that have been done in 1927 have made that year stand out as a pre-eminent year in aviation, and of course our attention has been particularly directed to aerial matters on that account. The Engineers Club, in thinking over the subjects which would be of vital interest for meetings during this present season, have felt that it would be particularly appropriate if we could have a meeting devoted to the special phases of aviation which have to do with safety, and so we have arranged this program; and we have come here this afternoon to hear some outstanding papers on that subject.

Aeronautical Insurance

By J. BROOKS B. PARKER

PROBABLY 99% of insurance covering aircraft today is on heavier-than-air, for the lighter-than-air craft have been so uniformly Government owned that there are but little insurance data available regarding them. The general situation today is that the insurance companies, who went into the covering of airplanes immediately after the war and wrote them freely in a helpful spirit, suffered such heavy losses that these are still uppermost in their minds. Other companies, that were not in aviation business at that time, of course know about the disastrous experience, and are loath to write it. For this reason, it is a matter of education of the companies to the facts that the planes and their operation today are entirely different from 10 years ago and that we have gotten out of a period when the insurance of planes was frankly bad into a time when the coverage can be written on selected risks with a chance of making a moderate profit, and are coming to a point where this business will be just as sound and just as profitable as other forms of insurance.

The principal forms of cover today are: Fire, Theft and Transportation, Accidental Damage (which I shall hereafter refer to as Collision Sustained), Tornado, Compensation, Public Liability, Property Damage, Passenger Carrying, and the problem of Life Insurance on those who fly.

There are covered under these forms: Property (hangars, planes, motors and equipment), the Public, and Employees.

Fire Insurance

Taking first the subject of Fire Insurance, in past years, as the occasional hangar was built, it was rated for fire insurance by a local Board of Fire Underwriters. As a result, the method of rating hangars varies in different parts of the country. Steps are being taken, through the good offices of one of the largest companies, to put fire rating on a uniform basis for aviation, so that those who have good hangars will not be penalized by some local inspector applying a basic rate which he may consider correct but which may be far too high. A really good hangar should rate between 1½% and 2%. I have seen hangar rates run from 1.48, which is the present rate on the new National Air Transport hangar in Chicago, the last word in safety of construction and operation, all the way up to 6.15 on a hangar in the South. A hangar in Utah was rated 3.75, and by changing the method of handling gasoline and of heating the building, the rate came down to 1.92.

It is the duty of every broker to show the manufacturers and operators how risks may be so improved that the possibilities of fire will be made very remote. It is only in this way that we can get the fire companies to realize that these risks are not always productive of losses and that they can quite properly lend their necessary assistance to this growing business by freely and willingly writing it. The occasional practice of fueling at the hangar door is, in general, bad. I say "in general," because there is very rarely a gasoline system such as will not allow free gasoline to drip from the plane or be exposed in a funnel. You can see that, if a strong fire should start at the door, there would be practically no chance to save anything else in the hangar. The practice of heating hangars and motors with open flames in the hangar is also particularly bad, and many of our worst fires have resulted from it. Parts should be washed in soda solution and not gasoline. Oily waste and overalls should be kept in steel lockers instead of wooden ones. The practice of running planes into the hangars under their own power should never be permitted.

I know of one instance when a plane was run into a hangar and the valve draining the carburetor and the gas line was opened with the motor running. A pool of gasoline was formed directly under the exhaust pipe. A fire resulted, naturally! You may think this sounds stupid. I grant you, I thought so, but you will find just the same type of carelessness in many of the operating companies. The saving feature of this case was the conduct of the personnel, who dragged the plane out and extinguished the fire so quickly that only a very minor loss resulted. Only yesterday, I was informed by a company that they would have to cancel the insurance on a new Fokker plane at a large field in New York, as the conditions surrounding it were careless and bad, and there was insufficient fire protection. Such an occurrence makes it necessary for the broker to do the same work twice or three times, in placing and replacing a risk, for but a single amount of remuneration, and goes far towards making the companies feel that all aviation is run on a careless basis. Things of this sort and the occasional fire, which is far too frequent, also brings this hazard so constantly before the underwriters that they are very loath to write this business. Please bear in mind that the safety with which you surround your construction and operation not only makes it possible for you to secure your fire insurance at better rates, but also, by reducing the frequency of these fires, improves the whole situation for the aviation industry. So much for the hangars.

The proper location of heating units and doping plants in factories has a tremendous bearing on the rate. Each should be located in a separate building, if possible. A minimum amount of dope should be kept inside the doping plant, with the remaining dope stored outside well away from the buildings in a small place of its own. The ventilation should be beyond question. The Keystone Aircraft, for example, has a large airplane propeller running at slow speed, at a point near the floor of its doping plant, which keeps the air comparatively free from dope and greatly lessens the danger of fire. The air in the dope room of that plant, indeed, is so free from dope that it is not unpleasant to breathe, whereas, in another plant with which I am familiar, it is all one can do to stay in the room while the dope is being applied.

When it comes to insuring planes, they must be covered wherever they may be and, in the case of fleets, a more or less uniform rate is applied to them all, so that they may have a flexible coverage. This fleet rate is governed largely by the fire rates at the hangars where they are usually kept, so it is evident that the fire rating schedule on the hangars themselves is a key point. The construction of the planes themselves is also an important factor. Careful consideration is being given, at the present time, by committees in many countries, to the desirability of classifying and rating planes in accordance with their construction. Vessels of all sorts are classified, and this classification serves as a very valuable guide to the underwriter. Our American Bureau of Shipping issues a register, classifying vessels built under their rules; Lloyds, of London, publish a register classifying vessels built in accordance with their rules; and the same is true of the Bureau Veritas, for French vessels. This last company has already prepared a register of aircraft, along the same lines as used for water-borne vessels, and it is only a question of time before Lloyds and the American Bureau put through something of the same sort for their respective countries. There is an international aircraft register under consideration, but I feel that such a register would not be so sound as the classifications in each individual country. At the present time our Department of Commerce is of great help to the insurance companies, in that it is weeding out the unfit planes and pilots by its methods of licensing.

Non-inflammable dope is an important item in the safety of planes. Most of the manufacturers and purchasers of aircraft object to the non-inflammable dope, now on the market, on the ground that it is not efficient as a dope and does not stretch the fabric as it should. If this dope can be brought to the point where it is satisfactory, its use would eventually make considerable difference in the rate charged, even if it were applied only to the fuselage of the plane, and surfaces surrounding the gasoline tank, filling caps, and exhaust pipes. I say "eventually," because all these things are a matter of education of the companies.

The reliability of the engines, on which Commander Leighton is to speak, has changed the attitude of the underwriters towards them. Liberty motors have gone from a point where they were not appreciated but rather condemned to a position where they are very highly respected. The Wright Whirlwind and others have, by their operation, convinced the underwriters that there is such a thing as extraordinary life and efficiency in the motors of today, and all of this contributes to the very complicated question of depreciation and obsolescence as they affect insurance values, particularly those of fire insurance and accidental damage insurance.

Theft and Transportation Insurance:

Theft insurance is not generally written, although a few planes have been stolen. This will be an important form of insurance in the future but is little used at present.

Transportation insurance is usually treated as incidental to the fire insurance and protects shipments in transit just as any other commodities are protected.

Accidental Damage

We now come to accidental damage, or collision sustained insurance, as I prefer to call it. There are so many factors involved in the rating of collision sustained insurance that you cannot say, as you might suppose, that safety in construction or reliability of engines are the major ones. The inherent stability of a plane, its performance in landing and taking off, its type of landing gear, all have a direct bearing on the rate charged. Safety of operation is also just as important, and the rates charged will come down to a point within reason just as soon as this safety can be demonstrated. At present, the rates run anywhere from 10% to 25% per annum, depending upon conditions of contract, performance of the planes, geographical limits in which they will be operated, fields from which they will be flown, experience of the pilots, and the integrity and ability of the operating company. An experience rating has recently been promulgated, in connection with one line whose record has been unusually good, and the saving produced will be over 15%.

Tornado Insurance

This is required in the Middle West on hangars, factories, and planes. There is little to say about rates, as these vary in different localities. The construction of hangars is important, however. When a tornado recently struck the National Air Transport hangar in Chicago it resulted in only tearing loose the edge of the roof for a short distance on one side, with minor damage of less than $100. As soon as most of the hangars come up to the standard of this one, the business will become so good that the companies will be clamoring for it. The same tornado picked up the new Ford 3-motored ship owned by the Standard Oil Co., of Indiana, and dropped it several blocks away. Because of the sturdy construction, the resultant damage was so small that the plane was soon put into service carrying officials of that company on important business trips.

Compensation Insurance

Compensation insurance, as a whole, has been unprofitable to the underwriters, and particularly so in the case of aircraft insurance. Rates are made by the compensation boards of states in accordance with the different laws of the several states. One state may give compensation to the amount of, say, a maximum of $10,000 for death, and another may limit this to a maximum of $3,750 for death, provided the pilot is married and has two dependent children. There is naturally a difference between the rates in these two states. Other states have no compensation laws, so it is necessary to take out employer's liability insurance. I have in mind an accident, which occurred in a southeastern state, where an employee of one of the large operating companies was injured. Because it was an employer's liability case, it was possible to collect for hospital bills and expenses without much formality, but it is hardly likely there will be any collection possible of the salary of the pilot, unless he sues the company that employs him. This is not entirely satisfactory, of course, but on the other hand, the rate for employer's liability insurance in that particular state is very markedly lower than in a state where compensation insurance, which would automatically pay the wages, is available. I am straying a bit from the subject, but am anxious you should know this as a complex form of insurance. Even so, it is subject to experience rating, if a company has few losses under a particular policy.

Public Liability

Public liability, by which I mean for injury by an airplane to any individual or group of individuals, that is, liability to the public, is, in my opinion, a lesser hazard than liability for injury by an automobile. On account of safety in operation over a period of time, two of my assureds have been able to get credits of more than 12% on the rates they originally paid.

Property Damage

The property damage hazard is not a particularly serious one, except for operators who must fly over cities. This is a form of cover which every one should carry, however, for it is impossible to tell when a plane may strike a house, or someone's automobile, or another plane, and damage it. On account of their care and experience, the saving I mentioned before was effected by the same company also on this form of insurance.

Passenger Liability

This of course covers the liability of the operating company for death or injury to passengers carried. The governing feature in passenger liability insurance is primarily safety of operation. Other features are, however, important. And example will illustrate. A Ford monoplane, equipped with three Wright Whirlwind engines, would seem to be an excellent risk, but in a particular plane I have in mind, one of the first built, the gasoline line was run so that there was serious fire hazard. The passenger liability rate on this plane came down over 30% after the gas line was reinstalled in a proper manner. Such a tremendous reduction indicates the penalty charged for the hazardous condition and shows how, in connection with passenger liability, also, direct savings can be made by safeguarding the risk. The recent accident to a Fokker at Hadley Field has not helped the insurance situation, in connection with this form of coverage, and seems to emphasize the importance of the old rule of the training field, not to be out of gliding distance of a possible landing field. This accident, and other minor ones that occasionally occur, should not, however, cause the underwriters to lose sight of the thousands of passengers carried each year, by operating companies such as the Pitcairn Aviation Co., Ludington-Philadelphia Flying Service, Potomac Flying Service, Curtin Flying Service, National Air Transport, Western Air Express, Boeing Transport, and all the big operating concerns, regularly, over great distances, with safety and comfort. More people are going to ride in airplanes, just as more airplanes are going to be built, and the insurance companies must appreciate the future possibilities of this business and not look only at present conditions, as I regret to say too many of them do. The reason for this is curious and a simple one. Most of the companies, for their own guidance, divide their business into classes and work out profits and losses on these classes separately. This system is fatal to any new business, for with an accident in the first year, wiping out the first year's premium, this business is treated as a sort of stepchild and barely tolerated if, indeed, it is not abandoned entirely. Consideration of aviation business as a class should and must be given up, and will be willingly by those companies that are looking into the insurance future.

Life Insurance

Life insurance companies cannot, at this time, freely write aviators, as the experience of the John Hancock has recently shown. There is too much accumulated hazard in one company for too small a premium income. The solution of this problem is one I know our Assistant Secretary of Commerce has been seeking, by proposing to combine the companies so they will share among many what would be serious losses to any one or two. By making such a combination, the companies could extend their policies to cover the hazard of aviation, which they usually specifically exclude for the first two years of the policy, and they could then accept people who contemplate flying, whom they will now accept only with a very high loading of rate, if at all. A small additional premium could be charged on the policies, and while this would be infinitesimally small when spread among the companies, in the same way the losses on people killed in aviation would be likewise infinitesimally small. I believe the actuaries of the companies could take up this matter with no appreciable harm to themselves, and with benefit to the aviation industry by helping us overcome what is at present a sharp deterrent to the man of means who would fly.

The effect on the insurance underwriters of the stunt flying that has been indulged in this year is the same as on the general public. Pride in planes, personnel and engines, coupled with a feeling of remonstrance against the unnecessary loss of life, has focused the eyes of the underwriters on these tragedies, and blinded them to the tremendous accomplishments of the commercial operators. They must realize that the splendid work of these men and the care with which they do it, has brought safety in aviation to the point where all the companies must carefully examine this as a future means of transportation. We have come to the point where such an examination is merited, and I am happy to tell you, in case you do not already know it, that many of the companies are making it. I believe, in the future, aeronautical insurance will come to the point where it will be easy to place, broad in its coverage, and at reasonable rates. Until that time we must, by every means in our power, show the insurance companies that the factors of safety being injected into the business are in their favor, and by keeping them actively interested, secure their support, which is so essential to the sound development of any means of transportation.

The Airplane Power Plant and Safe Flying

By LT. COMDR. B. G. LEIGHTON, U. S. N.*

I READ a magazine article the other day by a well known aviator who, in outlining his view of the future of flying, had this to say about airplane power plants:

"Failure of motor at night over land and at any time over sea or rough land, is one of the most pregnant causes of accident in all flying. I am convinced that if we can once reach the point where an engine never stalls in flight, we shall not average 5% of the tragedies we have today."

The inference is that 95% of all aviation accidents today are due to engine failures.

I think that pretty well sums up a general impression, widely held, even by many aeronautical engineers and airplane operators. It is a view that was in considerable measure justified perhaps, in the earlier days of flying, but a study of the aircraft accidents of the more recent past will show very conclusively that engines are responsible for far fewer accidents than is popularly believed to be the case.

In the early stages of flying, power plant failures happened so frequently that they came to be accepted as a sort of necessary and inescapable evil—almost as an Act of God. Engine failure was so common a cause for crashes in those days that a feeling grew up that, if a pilot escaped an occasional crash through engine failure, it was due rather to good luck than to good management. Engine failure served as a convenient explanation for all accidents that could not be otherwise explained. If a pilot had a forced landing or crash, a statement that the "engine cut out" was usually a thoroughly acceptable explanation, as complete in itself, almost, as if the pilot had said, "I was struck by lightning."

Old habits are persistent. And to-day, in spite of truly enormous advance in power plant reliability, we are very prone—largely from force of habit, I believe—to blame aircraft engines and accessories for many accidents in which the power plant is in reality totally blameless. Just last week, for example, at Anacostia, an airplane with a new engine installation crashed to a complete wreck just after take-off. The first explanation by eye witnesses was, "The engine must have cut out." The front page press reports stated definitely that the cause of the crash *was* engine failure. That was all pure guess work. The pilot of the plane had a quite different story to tell. He reported that the engine operated entirely normally throughout the flight, that he lost control of the plane for reasons in no way remotely connected with power plant operation, and that he cut his switch voluntarily just before the crash.

I will venture the assertion that if I were to circulate among this audience a questionnaire asking you to put down offhand the first thing that occurs to you as the most probable cause for the loss of the many airplanes that have disappeared in recent transoceanic flight attempts, the overwhelming majority of answers would be, "power plant failure." That *may* be the correct answer, to be sure. We shall never know for certain whether it is or not; but we do know that in the one case where reliable information is available—the case of the Dallas Spirit, which apparently went into a spin during darkness—the power plant was probably *not* the cause. [The forced landing of Ruth Elder just a few days ago, and I believe the forced landing of Snody, in his attempt to fly to Hawaii in the Navy PN9 two years ago, were due to plumbing failure, rather than true engine trouble.] I think you will all agree, after a careful consideration of all the circumstances attending these flights, and in view of the splendid record for dependability the type of engines used has established in this and other services, that power plant failure is a no more probable explanation than any one of several others that might be advanced, such as adverse winds, inaccurate navigation, or loss of control in fog, storm, or darkness. In this connection, it is significant to note that, of a total of 43 deaths in 29 fatal crashes in the naval flying service during the past two years, in every case but one, the power plant apparently functioned properly up to the instant of the crash. In other words, for one death due to faulty power plants, there were 42 deaths due to other causes.

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*In the absence of Lt. Comdr. Leighton, the paper was read by Lt. Comdr. H. M. Mullinnix, who interpolated several comments which are inclosed in brackets.

Some Actual Data

Here is the actual record of naval flying activities during the past two years, showing the influence of power plants on all crashes, injuries and deaths during the two-year period from July 1, 1925, to July 1, 1927. In these two years there have been a total of 186,698 flying hours in 261,762 flights in 67 different types of airplanes and seaplanes, using 12 distinct types of engines, in the hands of some 800 commissioned and enlisted pilots. The total distance flown has been roughly 15,000,000 miles. These flying operations include elementary and advanced training, experimental and test flying, oversea and cross-country flying, Marine Corps operations under fire in the hills of Nicaragua, racing service, record-breaking altitude flights, some pleasure flying perhaps, operations from catapults and carrier decks at sea with the fleet. The territory covered ranges from the Mediterranean Sea across the Atlantic and Pacific to the China Coast, and on to Australia. I think the records of our naval flying may be taken as a representative cross-section of what we may expect of heavier-than-air flying in all climates and in all classes of service.

We had a total of 377 crashes in two years—a crash being defined as any incident in flight where sufficient damage to the plane results to be a potential source of hazard to the flying crew—e. g., a landing gear failing on landing is considered a crash even though the plane be not otherwise damaged and even though the crew suffer not a scratch.

Of the 377 crashes, less than one-quarter involved power plant failure or malfunctioning as a direct or incidental cause. In the remaining three-quarters, power plants were in no way even remotely involved.

We had a total of 120 injuries to personnel—including minor injuries, major injuries, and deaths. Of these, about 10% occurred in crashes wherein faulty power plant operation figured as a direct or contributing cause. In the remaining 90%, power plants were in no way remotely involved.

I have already mentioned the fact that only one death occurred due to faulty power plant operation. This occurred in a DH-4 equipped with a Liberty engine. A broken oil lead from tank to engine caused a forced landing in rough ground, and the machine burned up. We have had no deaths due to power plants in any machine equipped with post-war engines, and in the last year there have been no deaths attributable to power plant failure in any airplane.

In summary, then, the records indicate that had all airplanes in the Navy been equipped during the past two years with an absolutely infallible power plant, totally proof against failures in flight for any cause, the result so far as safety to personnel is concerned would have been to reduce the number of crashes by 22½%, to reduce the number of injuries by 11½%, and to reduce the number of deaths by 2.3%.

A further detailed investigation of the cases in which faulty power plant operation *did* occur indicates that more than 50% of the power plant troubles were clearly due to laxness on the part of the ground crew or clearly negligent operation on the part of the pilot. Several cases occurred where the pilot took off with spark retarded, at least one instance in which the pilot took off with fuel tanks partially empty thinking they were full, and other cases of a generally similar nature. [I might mention one case where the mechanic forgot to shut off the pet-cock to the engine priming pump, and the excess gasoline feeding into the intake system produced an over rich mixture with faulty engine operation so that eventually the plane crashed.] Failure of the mechanism of the engine itself is so rare as to be practically negligible. Faulty operation is almost invariably due to some difficulty with the fuel or oil supply.

[Just the other day, before Miss Elder started, an officer with wide engineering knowledge was asked what, in his opinion, were the chances of her completing her flight without engine failure, and he said, "Roughly, 98%." Then he was asked, "Well, then, you think her chances of getting to Paris are 98%?" He said, "Oh, no. The plumbing, the navigation and various other hazards involved might cause a forced landing." But even with the conditions of heavy duty an engine would be subjected to in taking off with an overload of fuel, the chances of engine failure proper are more or less negligible.]

The Conclusion

What it all boils down to is simply this—that the modern aircraft engine has reached a point in its development where, if we give it reasonably intelligent care, it will continue to run almost indefinitely so long as we feed it fuel and oil. We have reached a point where we no longer can accept "engine failure" as a sufficient explanation or a convenient alibi for forced landings or crashes. The aircraft power plant has had a bad record in the past, to be sure, but the record of the past two years indicates that it has reformed.

[I would like to relate a little incident in that connection. The Boling Company put into service, between Chicago and San Francisco, last July 1, a fleet of planes equipped with Pratt & Whitney Wasp engines. They had some minor difficulties at the start, which were ironed out, but due to the large amount of flying done in that line, the engines rapidly piled up engine time. When they got to 150 hours, the pilots, who had been flying Liberty engines, thought it was time to pull the engines for overhaul. The engines were running perfectly well; there was no apparent reason for pulling them, except the accumulated experience with Liberty engines, which indicated that 150 hours was the safe period to operate them. The company insisted the pilots continue to operate the engines somewhat longer, until they showed signs of needing overhauling. When the engines got to 200 hours, the pilots were ready to mutiny. So as a concession, more or less, two engines were selected at random and completely disassembled for inspection and overhaul. As far as could be determined from that very careful inspection, there was no appreciable wear; the tolerances and clearances were all within the limits for new engines, and those two engines were re-assembled as they were and put back into service. The others haven't been pulled down yet. We don't know how long they will run, but certainly longer than 200 hours.]

I don't intend to imply that the power plant engineer has finished the job. So long as *any* failures occur, that is a lot too many. But I *do* feel we must all fully realize that, if we really want to reduce aircraft accidents, we must get out of our heads the idea all we have to do to make flying perfectly safe is to make the power plant engineer give us an engine that won't fail. The principal problem we must face now, in so far as engine reliability is concerned, is to reduce the plumbing failures, to so arrange the tanks and piping that there will be a continuing supply of fuel and oil. That is a problem for the airplane builder. The days when we could pass the buck to the engine have passed.

So much for the reliability and durability of the engine itself, considered purely as a mechanism.

The Weight Problem

But there is another aspect of the power plant problem, an aspect which is often overlooked, but which is of even greater importance to over-all safety in flight than is pure engine reliability. I refer to the problem of weights.

We are so accustomed to speak of airplane characteristics in terms of high speed, landing speed, climb, maneuverability, wing loading, factors of safety in structures, and what not, that these things loom prominently in our minds and tend very strongly to obscure the controlling factor which is at the root of all of them. That controlling factor is **pounds per horsepower**—power loading, in other words. It is, of course, possible to build a poor airplane having a low power loading, but it is entirely impossible to build a good—or a safe—airplane having an unduly high power loading. I sometimes think, if we could ask the gods to give us a divine formula for safe airplanes, the answer would be, "reduce the pounds per horsepower."

I have no hesitancy in saying, for ordinary everyday operations, I should feel much safer in a plane having a low power loading—and the flying characteristics a low power loading makes possible—even though the engine supplied were subject to occasional failures. I should feel much safer in such an airplane than in one loaded up to the limit, even though the engine were almost totally infallible.

We must not forget that (within the requirements of ordinary *practical* flight service) there is a fairly well defined upper limit to the total weight that can be carried per unit of power. Some one might build a freak machine seeming to belie this statement, but if you will examine various types of airplanes thus far constructed, I think you will agree that, in the present state of the art at least, it is impossible to build an airplane of any practical use, to fly satisfactorily with a power loading greater than 25 pounds per horsepower.

And when you consider that Lindbergh's machine weighed 23.6 pounds per horsepower, Byrd's 22.5, Chamberlin's 24.5; and when you stop to think of the poor take-off, landing, and maneuverability characteristics of these heavily loaded machines; when you stop to think of what happened to Lt. Comdr. Davis, when he tried to take off with a load of 25 pounds per horsepower, and of what happened to Fonck's machine when he started out with a load only slightly less; when you consider all these things, I think you will agree that 25 pounds per horsepower is about as close to the upper limit as any one will care to go, even for stunt work. For ordinary service, 20 pounds is about the upper limit. It is not just a coincidence that all modern weight carrying planes—both military and commercial—have a normal power loading of considerably less than 20 pounds per horsepower. Long experience has taught us that we cannot exceed this power loading with safety.

When we start building airplanes with *safety* as the prime consideration, we find the characteristics that are most important all require a reduction in power loading.

Do we want quick take-off and rapid initial climb? Power loading is the controlling factor.

De we want to build a multiple engine machine, so that if one or more engines stop we can still continue in flight? That requires a high reserve of power initially, and consequent low initial power loading.

Do we want a high degree of controllability at low speeds? That requires light wing loading, and if the airplane is to have any reasonable performance characteristics, the power loading must be correspondingly low.

Do we want our airplane to operate in the high altitudes of the mid-western plateau country? We must go even further in reduction of power loading.

The power loading of the Wright Brothers' first machine was in the neighborhood of 50 pounds per horsepower. The power loading of the average airplane of today is considerably less than 20 pounds per horsepower.

It isn't just a coincidence that increase in safety has progressed side by side with decrease in power loading. The former is the direct result of the latter. As airplanes have become lighter, they have become safer. They are safer *because* they are lighter.

I invite your attention particularly to the infrequency in fatalities due to power plant failures, by comparison with fatalities from other causes—notably, loss of control at low altitude—while the power plant has been functioning entirely normally. I feel very strongly that there is far more to be gained in safety through elimination of non-essential weight than will ever be gained through reduction in mechanical failures of power plants.

Bearing in mind that the practical upper limit of weight is somewhere in the neighborhood of 20 pounds per horsepower—and this limitation applies to all airplanes no matter what their size or shape—the whole problem resolves itself into a question of what is the best compromise distribution of the all too small total 20 pounds.

One thing we must always remember is that aviation is of no use to anybody except as a transportation vehicle, and therefore we must at the outset assign at least a portion of our limited 20 pounds to pay-load. The money we get for all development, for the establishment of airways and landing fields, for the construction of newer and safer and more efficient types, all must come in some way, either directly or indirectly, from the pay-load. We can never have *safe* flying until we have a *large volume* of flying, with enough dividends to pay for the establishment of all the tremendously expensive airways, and service stations, and landing fields, and organized weather service, and research laboratories, and inspection forces, which experience has already taught us are necessary.

And so we have a peculiarly complicated situation. Practical operation demands safety. Safety demands practical operation. Neither can progress without the other. And yet practical operation tends always to demand a higher pay-load per unit of power, at the same time that safety demands a reduction in the gross load per unit of power. We can't in safety increase the gross load, yet we must increase the pay-load. The only way to increase the pay-load is, then, to decrease the dead weights of structures.

Which brings us back to the original statement that there is even more to be gained in safety in practical flying through reduction in dead weight than through increase in engine reliability, important though engine reliability may be.

That principle has been the controlling factor in all our engine development in the Navy. We have concentrated principally on weight reduction and have let the reliability feature take care of itself, because we long since learned by experience that those features making for decrease in weight per unit of power output, usually result in more rugged and dependable structures.

There is more weight to be saved in completely eliminating a part than there is in skimping on its structural strength. And if we eliminate the part completely, we know it will never give us any trouble in operation.

As an illustration, the most important consideration in our determination to adopt the air-cooled engine was the reduction in weight resulting from elimination of the weight of radiators and water. At the time we came to this decision and discarded the water-cooled Hispano Suiza engine in favor of the Wright Whirlwind, there was no indication the air-cooled engine would be a more reliable mechanism. The actual fact is, the engine that has since developed into the Whirlwind was, at the time we adopted it for general service use, a distinctly less reliable mechanism than was the engine it displaced, even when we count in the troubles with cooling systems. I may add that today in our service a careful examination of the records of the last year does not indicates the air-cooled power plants have failed in flight any less or any more frequently than have contemporary water-cooled engines. But airplanes equipped with air-cooled engines are undoubtedly safer, because the weight we have thrown overboard, in eliminating radiators and water, has been translated into lower landing speed, better maneuverability, more rapid climb; or into increased pay-load, increased cruising range, decreased cost of construction and maintenance of aircraft, with consequent increase in commercial air activities, increased public interest and enthusiasm, which last is immediately reflected in increase in available capital to develop airways, landing fields, and all the other expensive appurtenances of a well organized air transportation system.

One important thing, which seems not to be generally realized, is that there is just as much gain to be had in reduction of weights in wing and body structures as is to be gained in reduction of engine weights. "A pound's a pound the world around." A pound of wings is just as heavy as a pound of radiator and water.

[If you analyze the 20 pounds per horsepower which Commander Leighton has established, you will find that roughly 10% at the present time is given over to the dead load of your plant, excluding fuel and oil tanks. The engine, complete with propellor and all parts necessary to run, may weigh from 2 to 2.6 pounds per horsepower. The total amount of saving possible in that power plant is not great, translated into percentages. If you save 10% on the weight of the power plant, you save, roughly, 1% in the gross load of the airplane, so there is more to be gained in reduction of fuel consumption, in increased economy of operation of present power plants, than there is in reduction of weight. However, every ounce that can be saved in power plant or structure is important.]

Thus far the airplane engine has borne the brunt of the burdens in the struggle for increased performance and efficiency and safety. Most of the real outstanding gains have come about as the result of departures from conventional practice. It would not be just to say the airplane constructor has not borne a part of the load, but there has always been, and still is, I believe, an undue adherence to convention in wing and body design features. There are many ways in which wing and body structures can be greatly reduced in weight, without making any concessions in structural strength. Many of them are unconventional, many of them seemingly expensive; but had we been afraid to undertake unconventional or expensive developments in the past, we would have no practical safe flying today. And if today we are afraid to try new methods because they are unconventional or expensive, we need look for no great advance in future.

The Air Commerce Regulation

By **MAJOR CLARENCE M. YOUNG,**

Director of Aeronautics, Department of Commerce, Washington, D. C.

THE Air Commerce Act, approved in May of last year, charged the Secretary of Commerce with the regulation of civil aeronautics. It created the office of Assistant Secretary for Aeronautics and established the Aeronautics Branch of the Department. The one and only purpose back of it is the promotion of commercial aviation—the development of its usefulness to the fullest possible extent in the United States where aviation found its inception.

We believe this can best be done by the promotion of public confidence in it—a confidence that will take it for granted in the same manner as it takes the automobile, the railroad, and the steamship—and that this can be accomplished only by bringing about the combination of four essentials:

1. Airworthy aircraft, efficiently maintained,
2. Competent pilots,
3. Suitably equipped airways, and
4. Standard air traffic rules.

It is the establishment of this combination that constitutes the objective of the Department, and is the premise of the Air Commerce Regulations which were drafted and made effective following the passage of the Act.

The organization with which to carry on the work is made up of four divisions as follows:

1. Air Regulations.
2. Airways.
3. Information.
4. Experimental.

In addition provision has been made for cooperation between the Weather Bureau and the Coast and Geodetic Survey for suitable weather service and airway map preparation.

Air Regulations Division

Referring to them in the order named, the Air Regulations Division presents itself for consideration first. It is charged with the duty of inspecting and examining aircraft, pilots, and mechanics for licenses, the identification of all aircraft not licensed, the enforcement of air traffic rules, the rating of airports and landing fields, and the investigation of accidents. Some idea of the volume and extent of the work at the present time can be gained from the fact that to date we have received over 8,000 applications for aircraft and airmen's licenses and for identification markings, to say nothing of the other phases involved.

Airways Division

The Airways Division is at present a part of the Bureau of Lighthouses, one of the old and established bureaus of the Department. Its function is the establishment, equipment and maintenance of airways. At the present time, there are approximately 11,500 miles of established airways, over which scheduled operations are being maintained, 4,121 miles of which were lighted by June 30, 1927, for continuous night operations, and 3,398 miles of which will be equippped with lighting facilities by June 30, 1928. These are aerial highways open to every aircraft operator and constitute a government aid of untold value to commercial aviation.

Air Information Division

The functions of the Air Information Division include the collection and dissemination of all sorts of information concerning the operation of commercial aviation both in the United States and abroad, the preparation of landing field bulletins, the distribution of Air Commerce Regulations and Airway Maps, the collection of statistical information for insurance and trade promotion purposes, and the development of such other informative material as will make readily available complete pertinent information concerning all aviation activities. The fact that we have had requests for more than 25,000 copies of the Air Commerce Regulations, since they were published in January, indicates the unusual interest in the present day operation of aircraft.

Experimental

The Air Commerce Act provided for experimental work in the development of additional aids to air navigation. This is being done at the Bureau of Standards, also an established bureau of the Department. Present work includes the perfection of the radio beacon and other radio aids, and the testing of aircraft engines, propellers, instruments and other aircraft appurtenances. The radio beacon is receiving major attention at the present time. It is a device designed to be of aid to pilots operating particularly at night or in unfavorable weather conditions.

Airways Maps

The Coast and Geodetic Survey have undertaken the preparation of Airways Strip Maps—a very important aid to air navigation. It is rather involved work and requires a very earnest effort to produce accurate results. It is hoped to prepare them for all established airways in due course. The initial work is under way and will be carried on as rapidly as time and funds permit.

Air Commerce Regulations.

In carrying out the provisions of the Act, one of the earliest problems was the promulgation of suitable regulations. Aircraft operations and activities in the United States were on a broader scale and more diversified than in any other country, and no satisfactory precedent was available. It involved a fresh start without the assistance of much in the way of a background. The regulations must necessarily take into account existing types of aircraft, including the war surplus and rebuilt, and, as well, anticipate the new construction of known types and the development of new; also, it was necessary to establish and define the various classes of licenses for airmen, both pilots and mechanics, and to prepare for their qualification by means of tests and examinations, including those for physical fitness. Standard air traffic rules were likewise essential, also regulations for the rating of airports, and adequate systems for properly identifying all aircraft, both licensed and unlicensed. It presented a difficult and complicated situation and a solution was not easily accomplished. The regulations that resulted represent the combined effort of many individuals over a period of several months, and reflect the favorable attitude of the entire aircraft industry, obtained at a series of conferences to which representatives were invited.

Licensing of Aircraft.

At the outset, the aircraft situation presented a real problem, as far as registration and licensing were concerned. We were confronted with all sorts of aircraft—the war surplus and the rebuilt, as well as new types and designs of more recent manufacture, all engaged in a great variety of operations. There were no fixed standards of airworthiness that could suddenly be made adaptable to the old as well as to the new, and it did not seem fair arbitrarily to rule out, as a class, planes that had been serving faithfully for so long, that had done the pioneering and kept aviation before the public during a very difficult period. It required the adoption of certain definite requirements for the future, tempered somewhat by the necessities of the immediate present.

Also, it was not a simple matter to assemble the personnel of an organization to handle the inspection and licensing phase of it. It required men with unusual qualifications. They must be pilots of more than average ability; they must be thoroughly experienced in aircraft operation, inspection and maintenance, including aircraft engines; and they must be possessed of a suitable personality; also they must know the Air Commerce regulations, and thoroughly understand and be in sympathy with the policies and aims of the Department. Such men are not plentiful. They must be brought in and trained. This phase of it also presented a problem.

We are now under way, however, and the inspection work is being carried forward as rapidly as circumstances permit. Existing airplanes of known construction and proven performance are being licensed, if found in an airworthy condition upon inspection. New types and designs are required to submit complete technical data, and to meet certain performance requirements before they will be considered for license.

There is a present interval during which some airplanes, such as the war-surplus types, are being accepted without other than a rigid line inspection. It is rather a transition period. The time is almost at hand, however, when the Department will require complete engineering information upon all aircraft, before considering it for approval. It will mean the elimination of certain existing types, or their relegation to the unlicensed and intrastate class, but it is the only way in which licensing can become really effective and proper control exercised.

Pilots and Mechanics.

The licensing of pilots and mechanics—called "airmen" in the Air Commerce Act—has its complications but not to the same extent. Certain standards were arbitrarily set up and examinations and tests formulated in accordance therewith. They include, in the case of pilots, not only a practical demonstration of piloting ability, but also a good knowledge of aircraft and engine maintenance, and the fundamentals of operation, including air traffic rules; also a showing of physical fitness. Mechanics are qualified by both theoretical examinations and practical demonstrations. Pilots' licenses are issued for either six months or a year, depending upon the class thereof. They are subject to renewal upon a showing of continued physical fitness and a minimum of flying during the interval.

The most airworthy airplane built is not a safe vehicle in the hands of an incompetent pilot, and our effort and tendency is to become more exacting in the requirements for pilots' licenses, especially when the transportation of passengers is involved.

Aircraft Maintenance.

The maintenance of aircraft in a continued airworthy condition presents difficulties from the Department's point of view. An airplane may be in excellent condition and airworthy today, and quite otherwise tomorrow. Obviously, it is not possible for our inspectors to maintain a daily inspection system, nor is there a desire to do so under existing circumstances; it would call for too much supervision and hinder operations. Rather, the regulations impose upon the owner or operator the burden of maintaining his aircraft in an airworthy condition. Also, they provide for daily and periodic inspections by licensed mechanics, and require suitable entry in log books which are open to scrutiny by Department representatives. Unannounced inspections also are made by Department inspectors when opportunity is afforded. The future plan, in this respect, is to have inspection districts small enough for the inspector in each to know, and maintain a contact with, all aircraft and operators within it, thus furnishing a more efficient service in the enforcement of air traffic rules, the investigation of accidents, the inspection of aircraft, and otherwise to assist in maintaining a uniform standard in all aviation activities.

Aircraft Manufacturers.

The airplane manufacturing industry presents a rather exceptional situation. The unusual existing commercial demand for airplanes was not anticipated and there is a real shortage of new planes; the demand for a number of types and classes exceeds the supply. Production is being increased as rapidly as circumstances permit and the commercial aircraft industry as a whole is taking on the aspects of a staid, fixed and very definite business.

In making plans for our organization for the ensuing year, we have tentatively discussed one hundred planes per month as a possible addition for the year. The representative of one manufacturer was in my office last week and made the statement that his company alone planned to produce and market twelve hundred during that period. It suggests the probabilities involved and indicates quite conclusively that the era of aviation is a thing of the immediate present.

Appropriations.

At this point, it may not be amiss to parenthetically insert a statement with respect to the appropriations for putting into effect the regulatory provisions of the Air Commerce Act. There are two appropriations under the Act, "Aircraft in Commerce" and "Air Navigation Facilities." The total appropriations for both were approximately four million dollars for the current fiscal year. Of this total, over three millions were for the establishment and maintenance of airways. The remainder was for all other Departmental aviation activities, which permitted only about $350,000 (exclusive of $113,000 for the purchase and maintenance of ten airplanes) to be made available for the enforcement of the various regulatory provisions of the Act. It is necessary to be mindful of this fact when consideration is given to the accomplishments along this line during the year. As previously stated, over 8,000 applications have been received thus far. The daily receipts still average about fifty, and there is no indication of a decrease in the near future.

State Regulation.

The question of state legislation on the matter of inspection and licensing is of real importance. As it is now, the Department of Commerce, being a Federal agency, has control over only interstate flying, so far as licensing is concerned. While it is empowered to, and does, require that all airplanes carry identification numbers, whether or not they are engaged in interstate commerce, it cannot establish minimum requirements for airworthiness, in airplanes operating solely within one state. As a result, airplanes that are condemned by the Department's inspectors and refused licenses for interstate commercial use, may obtain identification numbers and operate within their own state, carrying passengers or property. This situation should be altered by legislative action, during the next sessions of the various state legislatures. Until it has been done, effective regulation of all aircraft is impossible. And since the layman will not consider the airplane a really safe means of transportation until regulation is general and accidents are reduced in number, some action must be taken, and that as soon as possible, to eliminate the condemned or unairworthy airplane completely. It makes no difference to the man in the street, if he reads in his newspaper that an airplane crashed yesterday, if there were one, whether it carried *identification* number 1,000 or *license* number C-1,000. That the *identified* plane *might* have been any old "crate," while the *licensed* airplane *would* have been inspected and passed as airworthy, would doubtless be ignored. All he would gather from the news would be that another airplane crashed and his faith in the dependability of air transportation would correspondingly decrease.

Pennsylvania has enacted suitable legislation, but most states have not, and it is a subject requiring earnest consideration.

Airports.

The Air Commerce Act provided for the rating of airports and landing fields, upon application. It is not compulsory, however. The result is that airworthy aircraft and licensed pilots may operate from fields that are entirely unsuited as to size and equipment. It introduces an element that does not make for safety. Several accidents have been reported and, on investigation, shown to have resulted from such a condition—the field being either too small, or not properly equipped or managed, to protect the crowds that surged around the planes with their propellers in operation. A suitable remedy for this should be developed and provided.

Conference.

The experience of the past year has been very valuable. We have found our Regulations entirely satisfactory in some respects, and quite otherwise in others. Also, many matters calling for consideration have been brought to attention. It is in the light of this that a conference, of those interested in the proper advancement of aviation, has been arranged for the week of December 5th, for the purpose of considering certain important changes in the regulations; as well as other phases of the industry, such as the operation of airports, the conduct of schools of aviation instruction, the suitable testing of new aircraft engines, propellers, instruments and equipment; and at the same time, of giving consideration to the various services rendered by the Department, with the hope of improving upon them.

Conclusion.

There are many problems confronting the Department in the matter of regulation. The satisfactory solution of them, of course, is at times exceedingly difficult. However, much has been learned and accomplished in the few months of operation and there is reason to believe that the near future will see very definite progress in bringing about the combination of the four very essential elements in the successful operation of commercial air transport, airworthy aircraft, piloted and maintained by competent personnel, and operated over safely equipped airways and in conformity with standard air traffic rules.

Modern Aircraft Structural Materials

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BEFORE taking up my paper, I want to announce that I have a telegram which I think will be of interest to you all, although it brings news which all of us regret to receive. It is a telegram which came from Commander Leighton, who was to have presented a paper here, and reads as follows: "Suggest you pay tribute to the memory of Mr. Charles Manley, who died yesterday. In 1901 he built the first really light aeroplane engine which pulled 52 horsepower for ten hours with a gross weight of 124 pounds. He is the father of the modern radial engine. After more than twenty years of wandering afield, we have come back to the form which his clear vision foresaw in the beginning as the fundamentally sound arrangement for truly light engines. Modern aeronautics owes him a debt of gratitude."

To that, I would like to add that I knew Charles M. Manley for a good many years, and I had principal contact with him at Buffalo during the war. The work he did there touches on work which we are very much interested in today, and that is integrity of inspection. He was in charge of the Curtiss inspection force when they were at the greatest peak of production during the war. His aim was that the Curtiss inspection force should be a real inspection force, and that anything his inspectors marked as being O. K. was O. K., and that the Curtiss reputation was back of it, and he very insistently put before his inspectors that that was what the Curtiss stamp meant. The result was that when we came to put Navy inspection on the product of that plant, we had a fairly simple task, for our work was supervisory inspection, and what we had to take care of largely was what the Curtiss inspectors rejected and the determination of the best disposition of that material, because rejections meant not always that the stuff rejected could not be used, but it meant that it was not perfect. We could in many cases cut the material—largely it was wood in those days—and use it over again for other parts. Other parts could have certain treatment which was a perfectly logical thing to do, but which the inspectors did not have any license to pass.

The subject assigned me is "Modern Aircraft Structural Materials."

Primarily, structural safety in airplanes depends upon a correct determination of the loads to be carried by different members of the structures, and the adaptation of suitable materials correctly proportioned and attached to carry these loads. Trite, isn't it? In other words, make every part so strong it won't fail. But just there is the rub. If we make each part strong enough for every conceivable loading in flight, it is highly probable the plane won't fly at all, or that it will fly badly; it won't be a good flying machine.

The correct determination of the loads to be carried is complex in itself. The conditions of flight impose a variety of loadings, some members are lightly stressed under some conditions and heavily stressed under others. It is possible to investigate all conditions conceivable, but it is soon found that certain conditions dominate, and that if these principal conditions are met, there is adequate strength for other conditions. Customary analysis covers, high incidence, low incidence, inverted flight, and landing conditions (including level, three point, and crosswind). For these different conditions, suitable factors are applied based on experience, and this is the basis for design specifications. Military, particularly naval aircraft, have particular requirements, due to their employment, which are more severe than those imposed on commercial types. I shall not deal with these, except to mention acrobatic, catapulting and deck arresting, and hoisting.

Much is gained at once if commercial flying is limited to those maneuvers necessary to make usual landings and take-offs, and proper approaches to the usual landing fields, with some leeway for emergency landings. In addition, there must be maintained, between the periodical overhauls, strength adequate to combat the stresses of turbulent air. The landing conditions for seaplanes form a particular case. The structure must be firm, prohibiting excessive distortions under loads affecting aerodynamic qualities and also eliminating any tendency to fluttering. It is rather remarkable what the effect of fluttering is. During the war, in testing out one of our planes, we wanted to put a balanced rudder on. It was the NS type of plane and we put one on of about a square foot in area. Our design specifications called for a loading of about twenty pounds per square foot as the design load for the supporting member. We took the plane out for a flight to test out the balance, and although we had previously redesigned and reinforced that member, after flying for a short time, I found that, instead of carrying right rudder in that type of airplane, I was carrying left rudder, and when I came to make a turn I could make only a flat turn. I finally got around,—I had to turn around on account of running into the mouth of the Niagara River—and when I got straightened away, I look back to see if there was any explanation of the condition, and I found this overhang had bent over about 45 degrees. Now there was no conceivable loading, that that rudder could have gotten from direct load, to explain this: it was merely the vibration pulsation of the slip stream that had caused that failure. Often, wings have fluttered in flight, due to the ailerons not being balanced on their hinge axis. The result is the pulsating of the wing, and the overhanging weight causes the aileron to vibrate in unison with the period of the wing; wings have been torn to pieces under those conditions. Once fluttering starts, it is difficult to stop.

The adaptation of suitable materials is now leading strongly to allow steels, light alloys, and non-corrosive alloys, for the structural members, and in some cases even for the covering of the wings, fuselage, and tail members. As in general the latter practice tends toward weight, the effort is constantly being made more or less successfully to utilize the surface as part of the structure, but to date the lightest structure results from making the framework of metal and the covering of fabric suitably attached, doped and finished.

The use of metal fuselages has contributed greatly to the reduction of casualties in minor crashes and largely to the elimination of fatalities in even serious crashes; so that stick and wire construction is rapidly disappearing, and monocoque construction is rare.

The Post Office Department for a long time used the DH airplane. They modified them for mail purposes. One of the modifications they made was very important; in the pilot's cockpit they doubled the veneer. The original DH's were covered with veneer on the outside; in these mail planes they covered the cockpit with veneer on the inside, so it was double strength in that compartment. In a number of severe crashes—very severe crashes—that were suffered by those planes, the pilots escaped with minor injuries. If those cockpits had not been reinforced, lives undoubtedly would have been lost.

Metal framed tail surfaces and ailerons are becoming common. Metal wings are still experimental but metal ribs for wings are now generally coming in. Interplane struts and landing gear struts of metal are very general.

In this country, welding of steel, particularly chrome molybdenum steel, is very generally accepted as satisfactory practice, with the limitation, however, that welds in tension are not considered reliable. To avoid this, it is usual practice to introduce gussets at joints, or long scarfs in which adequate welding is presented in shear; and where the loads are high, it is usual to slot the gussets through the members to gain additional shearing values. In such cases, it is also usual to incorporate in these gussets the attachment lugs for connecting other members. Electric and gas welding are acceptable, acetylene welding is considered as hazardous. In all welding, since it is impracticable to determine the interior condition of a weld by inspection, it is considered essential to have this work done by skilled and reliable workmen. Local reinforcements are often accomplished by brazing. If brazing is to be associated with welding, it should be done subsequent to the welding.

Experience with properly welded jobs in crashes leads to confidence in its use, as it is generally found that welds are rarely parted, though adjacent members are twisted and torn. A good weld is, in effect, a casting, of superior quality to the metal from which formed. Particularly in the case of column loading, the strength of the column is not damaged by the welding at the ends.

It is still considered good practice to form the engine mounts, the wing base portion of the fuselage and the cockpit portion of steel alloy, though it is rapidly becoming the practice to use light alloys for the rear portion of the fuselage.

Metal wing spars are coming, but at present are costly. Considerable success has been had in England with corrugated watch-spring steel. Numerous good aluminum alloy spars have been built in this country but they are expensive and save little, if any, weight, in ordinary types of planes, over what would result in a good design of wood spar. One striking advantage of the use of metal is the uniformity of quality of the parts, as compared with wood, and the relative ease of securing adequate fastenings. Even with wood, the joints were practically always of metal and, in highly stressed parts, of alloys.

Considerable progress has been made in bolted up fuselages. This is expensive, but is readily inspected and repaired. Ease of maintenance is one factor which retards the adoption of metal covered surfaces. This is important in relatively thin surfaced biplanes, but of less importance in thick wing monoplanes. I mean, it is possible, in the larger winged monoplanes, to crawl into the interior of the wing and determine its condition. With the thinner planes, biplanes, you have to open up the structure or provide inspection holes.

The situation in regard to alloy steels and light alloys is, generally, alloy steels are readily welded; light alloys can also be welded but unless heat treated after welding are subject to accelerated corrosion. Again, where the loads are high, steel is preferred, as the design usually involves a sufficiently heavy gauge to make crinkling due to secondary stresses unlikely, and to avoid dangerous reduction in strength due to corrosion. However, where the stresses are light, light alloys are preferred, as, for the same strength, the gauge will be heavier than if steel were employed, and, if the latter were employed economically, there would be danger from crinkling and from corrosion.

Corrosion is particularly dangerous in thin metal. In any case, adequate means are required, particularly on inaccessible portions, to prevent corrosion. Suitable means have been found for this, and improvements are constantly being sought In Europe, particularly in England, so-called stainless steels are being used, particularly in composite steel and light allow structures.

Metal hulls and floats afford such an appreciable saving in weight primarily, and secondarily, through the elimination of soakage, that, even though corrosion or electrolysis is presented in its most difficult phase, these are rapidly coming into general use. With frequent inspection and proper maintenance, they are highly satisfactory.

Power Plants and Installations

The trend in this country, particularly in the Navy, is toward aircooled power plants. Safety is found, here, in the elimination of the plumbing and installation troubles associated with the water cooling system. Maintenance of the engines themselves is simplified and this means safety. Further, it is usual to have the carburetors and leads well separated from the ignition system, thus reducing the hazard of fire.

Add to this an important saving in weight, with the fact that in practice the touted loss of speed, due to the exposed cylinders, is found to be negligible, in the light of the weight saving and its effects on the design as a whole, and the reason for the rising popularity of aircooled engines is found. Aircooled engine economy of fuel consumption and oil consumption is on an equal if not higher plane than that of the best watercooled performance.

Power plant accessories, spark plugs, ignition wiring, magnetos, switches, carburetors, starters, are continually improving and today are quite reliable. I wish the same could be said for the plumbing. I mean the gas tanks, oil tanks, strainers, and piping. I believe that today this is the weakest link in the chain of reliable power plant installation. I can only advise that, this being the case, it is the part that must be given the most careful attention.

As to instruments, great progress has been made but improvement is still possible and demanded.

In the interest of safety, I consider that the turn indicator has not had sufficient attention. In thick weather it is essential, but its mere presence is not enough; its use must be practiced in fair weather, in conjunction with the compass, the inclinometer and the air speed meter or the tachometer. I am confident that Lindbergh's success was in a great measure due to the practice of instrument flying, and that a number of disasters have been due to inadequate preparation for this type of flying, at night, in clouds and in fog.

I stress the turn indicator, for by its use the plane can be kept from turning, where any type of compass may prove false; if the plane is kept from turning, the inclinometer will tell the truth, and if the plane is kept level and at flying speed, the compass will tell the truth, and the true course can be found and maintained. But without the turn indicator, the plane may bank and turn without its being indicated, the compass may spin, and the plane may spin and crash.

Navigation

Navigation in thick weather may be facilitated by the radio beacon; it is near success, and will soon be in practicable form for general use.

There still remains the determining of the location of the landing field in thick weather; until that is accomplished, we must depend on the best possible meteorological service and the communication of conditions to planes in flight by radio, supplemented by hard-boiled administration of flights and numerous emergency fields on established airways.

When I call for hard-boiled administration of flights I have in mind the number of accidents that have happened because planes have been allowed to take off when they should have been held in the field.

In closing, I want to plead for more serious consideration of the merits of seaplane operations over the wonderful water-ways and coast-line of this country. Our principal cities are largely located on bodies of water forming adequate bases of operation with, in many cases, closer access to the heart of the city than can be afforded by suitable landing fields. Even land fields are safer if approaches or take-offs can be had over water rather than over congested districts.

Safety from Aerodynamic Design

By LIEUT. EDWIN E. ALDRIN, U. S. A.

I SHALL merely try to outline this large subject, and will not be so ambitious as to attempt to make a guess as to how to solve the problem. The Guggenheim Fund has put up a large enough prize to attract anyone that can do it. If I could do it, I would try for that prize.

Safety Is Relative

Some consider safety achieved by staying on the ground and waiting for good weather. We have to get safety combined with a reliability comparable with that of existing means of transportation. Under this caption, it must be stated that there is a great difference between regularly scheduled flights and intermittent flights. The former is supposedly highly organized, and the pilot knows very closely, for example, the altitude of large obstructions. Take, for example, yesterday; I left Dayton at noon, intending to come to Philadelphia. That route is not a regularly charted route on the Army Airways maps. The Dayton to Washington route is, however. I was forced down by rain at Cumberland. That was an emergency station on the Washington Route. If I had known the topography, the altitude of the mountains and so on, I think I could have pushed through yesterday, direct to Philadelphia, but that is the kind of problem that comes up in connection with flights over uncharted routes and of an intermittent nature.

Assuming normal engineering precautions and design, as employed at the present time, such as, for example, center of gravity location, and proper tail surfaces, so you can bring the tail down in landing, there are many phases of design, from the viewpoint of aerodynamics, that can stand greater experimental effort in order to reduce liability to serious accidents. In other words, there is much to be done to achieve greater safety, from design from an aerodynamic viewpoint. We of course are all interested in this. The Army is interested in it particularly in connection with transports and ambulances; the commercial operators naturally are the most directly interested. The big advantage of the airplane is its high speed, as compared with other means of transportation. Without sacrificing any of the practical qualities now possessed by the airplane, we should have:

1. Full control at low speeds,
2. Reasonable stability,
3. Slower landing speeds when required,
4. Steeper climbing angle after a reasonable run for take-off,
5. Variable glide by straightforward flight (without stunting),
6. Safe landing from a stall (unless the latter can be properly guarded against).

That is the general problem.

Simplicity is the keynote of safety. Trick gadgets should not be applied, unless they themselves are foolproof or simplify the general procedure of flying. At the present time, the general tendency, in case of a stall, is to pull back on the stick; in other words, to keep the nose up. With the general type of aircraft now existent that may be fatal, under many circumstances. I wish to plead for greater effort in experiment and research on this whole problem. We may surpass Europeans in performance and demonstrations, but our technicians must admit that we get our original data in most things from the magnificent pioneering done in England, France and Germany.

Accident Analysis

There was an accident analysis made for the year ending June 30, 1926. That analysis considered accidents from two different points of view, that of the first thing happening to precipitate the train of events finally resulting in the accident, and that of the final event itself, the accident proper. Of course, the category, "error of judgment," generally gets overloaded. If most aircraft statistics are investigated at the present time, you will find that "error of judgment" is blamed much more frequently than anything else.

Let us analyze further. Under "initial cause," in other words, "what precipitated the chain of events," it was found that the power plant, with its installation, was responsible for the greatest number of accidents, that is, precipitated most accidents injurious or fatal to personnel. That, mind you, is contrary to a remark previously made here, but when you permit "error of judgment" being taken out of this discussion, it makes the story a little bit different. We would not progress much if we contented ourselves to blame an accident caused by a retarded spark on error of judgment. I blame the installation—we have automatic advancing on automobiles. Of course, this involves the question of statistics. Statistics can at present usually be wielded around into any form into which we wish to put them.

The cause, second in importance, is structural failure. By that is meant everything that can be charged against the structure, like a wheel breaking, the landing gear collapsing, and so on. And of third importance as an initial cause of bringing people down, is the weather. But that did not result in any fatal accident.

Now those are all initial causes. Even if we had all those initial causes, we could still avoid most of our accidents if the final cause were removed. The most frequent final cause of accident is what is termed the "flying quality" of the airplane, or the aerodynamics of the airplane, all that is comprehended in the problem outlined above. The next important cause was found to be lack of proper landing facilities.

There may have been considerable improvement since this study, so that accidents today might not distribute exactly as that study showed, but there seemed to be an equal distribution of initial causes between take-off, landing, or normal flight in the air.

Low Speed Control

Control at low speeds has not been attained in ultimate form as yet. For some time back, the British have been doing a lot of experimental work on lateral control. Captain Courtney, of England, has criticized them, as giving too much attention to control at or beyond the stall, when we have failed to remedy the serious situation resulting from the stall near the ground, from stalling itself. He is largely right, but longitudinal control will come as soon as we know enough about lateral control. Most present machines, when stalled, will "nose-dive," taking a rate of descent much greater than in a glide. For an aircraft sustained in flight by fixed wings, there are then two remedies: an emergency postponement or total elimination of the stall, or a general compromise, by keeping the nose up under full longitudinal and lateral control, and squashing down onto a long stroke oleo gear. Figure 1 shows the effect of stalling an airfoil, and causing what is termed "burbling," which is familiar to most of you. The Germans have devised a scheme for correcting this, by preventing the breaking down of the boundary layer. "Boundary layer" is a term applied to the layer of air very close to the airfoil surface, and its continuity is necessary to be maintained or streamline flow is broken down. Air is supplied to the upper surface, the suction side, and the boundary layer is continued. Air has been supplied to that suction surface in models, making it possible to maintain good streamline flow at a stalling angle. The objection

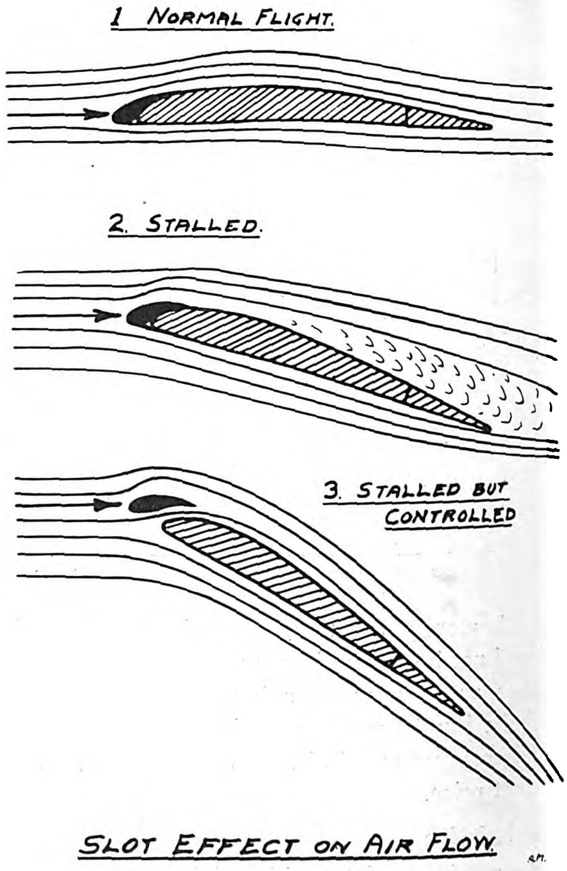

FIGURE 1

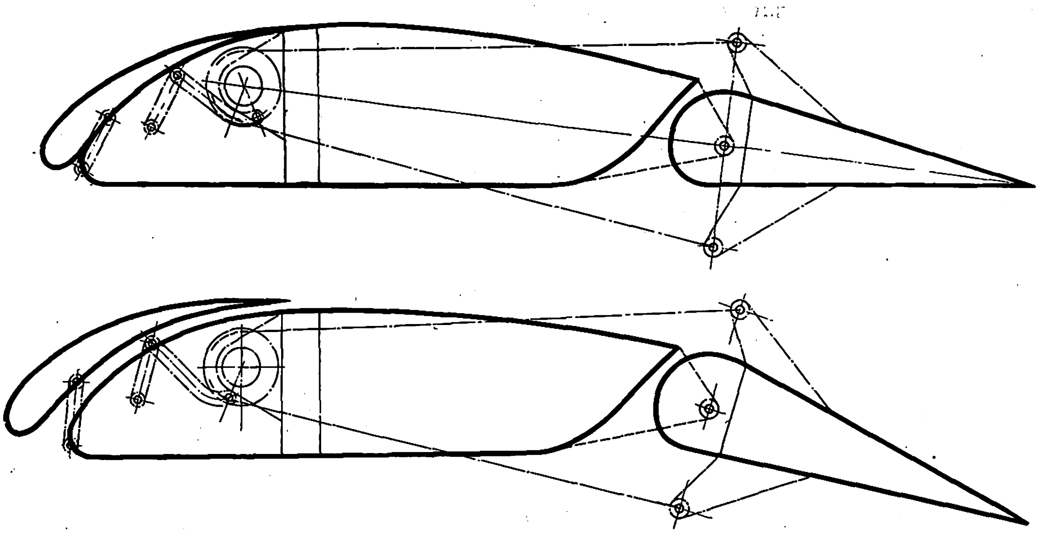

FIGURE 2

to it was that the quantity of air required was too great. The N. A. C. A. organization at Langley Field have tried this on a TS-1 airplane, using a Roots blower, but found little or no improvement. That may be rectified in the future, but another way of tackling the problem is to allow the air to bleed in from the other side. That leads us to the question of slots, of which more later.

One remedy for the stall we are considering has been attempted in the Autogiro of La Cierva, flown so successfully in England. But to return to the slot and flap, the Handley-Page, applied to a Bristol fighter, has increased the lift coefficient in flight for the entire machine from .55 to .855, quite an increase. Just recently the automatic slot or "slat" on the leading edge of the airfoil has been announced by Handley-Page. At high angles of attack the slat is blown out into extended position, as in 3, Fig. 1. When high speeds are attained, the wind coming at a low angle to the wing chord, blows it back down against the airfoil.

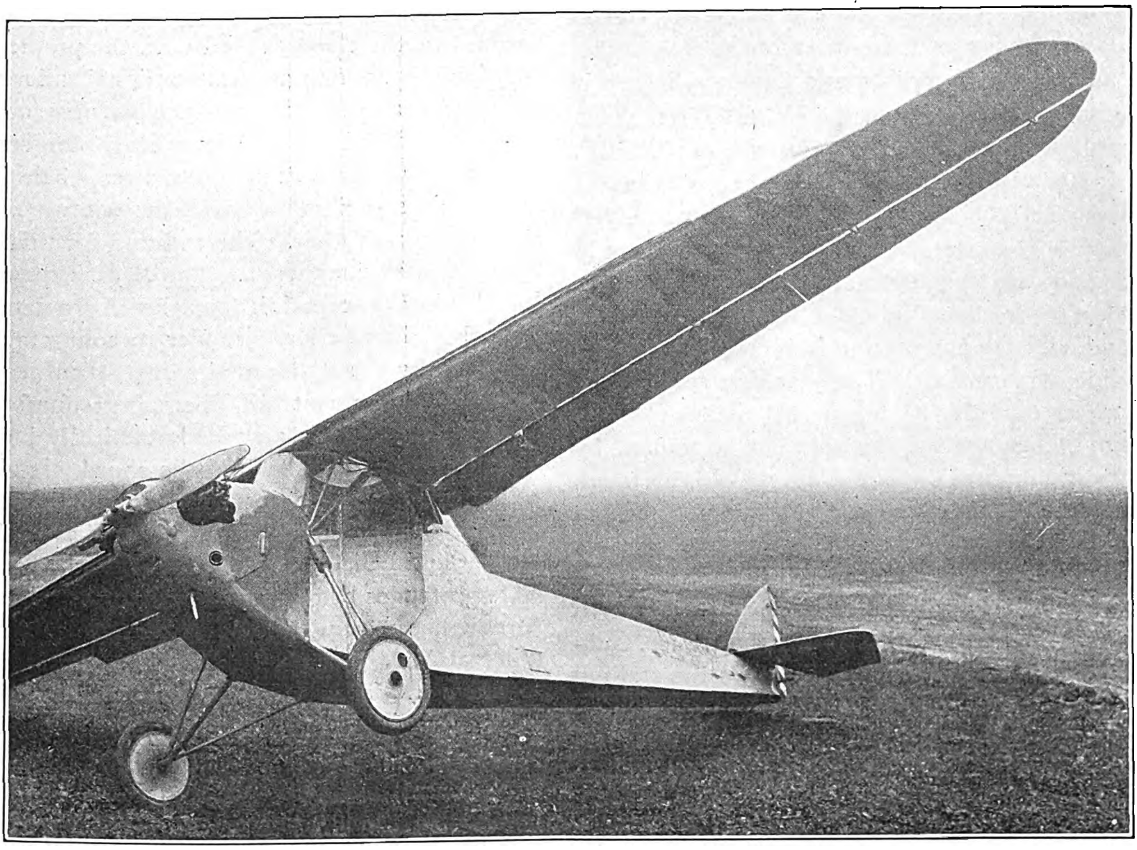

FIGURE 3

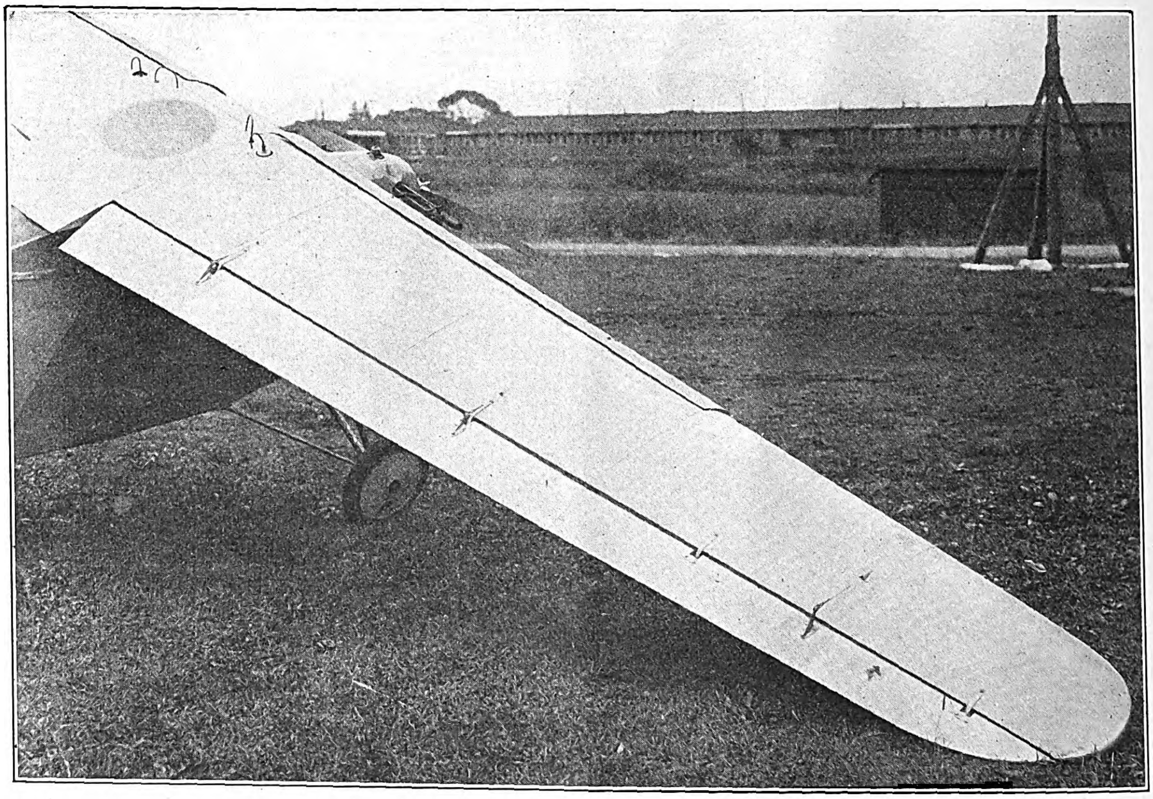

FIGURE 4

This is a great advance, but what will happen in case of sleet remains to be seen. In Germany, Lachman, Betz, and Wieselsberger have done a lot of pioneering work and the slots and flaps have been applied to various types of machines, including the Junkers. In the United States, so far as I know at the present time, the only machine having slots and flaps applied to it is one we have out at Dayton, the Driggs Dart. This is a very light machine, powered with a 30 H.P. Wright Moorehouse engine; the object being to have a sort of flying aerodynamic laboratory to try out, full scale, such things as slots and flaps. The departure in this particular case can be found in the form of the leading edge of the flap, Figs. 2-4. This edge is perfectly round, and the flap section is symmetrical about a center line fore and aft. The machine reduced its landing speed roughly 10 m.p.h. by means of this mechanism. Then we see the solution attempted by means of variable areas. The Dayton-Wright racer, which was entered in the Gordon Bennett Race in 1920, was an example of that. And we have variable camber, and that in combination with variable area. Another way out is by means of the Savage-Bramson anti-stall gear. In brief, that is a contrivance, substantially a wind vane, for indicating when the stalling speed is approaching, and it may be set to automatically push forward the control stick, so the machine will assume the proper attitude or angle of attack. Once under longitudinal control, with stalling postponed, the problem is rather a different one. If we have sufficient and properly set horizontal tail surfaces, to maintain trim for the backward movement of the resultant air force, or if we can compensate for it by means of quickly movable ballast, such as water, we can get around that difficulty without much trouble.

For lateral control, we have still another problem, because that is closely allied with the problem of autorotation or spinning. Conventional ailerons, when operated near the stall, produce yawing moments, almost the equivalent of the rolling moment desired[*] Spinning or autorotation commences when the yawing moment is sufficient to make one wing move forward faster than the other. The solution for this can be attempted in various ways. The British have tried and found very successful, on the Avro and on the Bristol Fighter, a large rudder to counteract the yaw produced by the standard ailerons. Another way is by forms of aileron control. There are a number of them. The Frise aileron is an aerodynamically balanced aileron, hinged at 25% back of the chord. It gives better characteristics, with respect to yaw, than the usual aileron. When pulled down, it is similar to the present aileron and bad in yaw. When pulled up, its leading edge protrudes below the lower wing surface and tends to equalize yaw with a down motion on the opposite wing, and at the same time balances the force required to move it. Then we have the slot and aileron control, an adaptation of the Handley-Page-Lachmann scheme of allowing air to come through to the upper surface and thus smooth out the flow or burbling occurring on these. That method has been found best in combination with the complete airfoil having slots and flaps. Also, ailerons have been placed between the wings in a bi-plane structure, the floating type, but they offered too much resistance to high speed. Another device is the spoiler gear. Lieut. Harper, of the Navy, developed this gear, which is a sort of interference to be raised on the wing we want lowered. That is, in order to get the rolling moment, we raise up, on the upper part of one wing, a sort of "spoiler" to spoil the lift on that wing. It is best in conjunction with ailerons after they have been moved about five degrees. The spoiler has the effect of causing additional loss of altitude. Plan form of the wings also helps in certain cases. Tapered wings have been found of advantage in assisting control at low speeds.

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[*] See Mackinnon Wood lateral control diagram, Tech. Memo. 280, U. S. N. A. C. A.

Swept-back wings, swept back to 25 degrees in monoplanes, have been found in tests at Technology to be spin-proof. That is a quite broad statement, but is according to the information given out. We have an extreme case of swept-back wings in the Burgess-Dunne, one of the older machines, and in the Hill Tailless Pterodactyl.

Another contrivance is washing out the wings, changing the angle of attack, or angle of incidence, rather, of the wings as you move out from the center line of the fuselage to the wing tip. "Washing out" means raising your trailing edge relatively to its position near the fuselage. This may be approximated by rigging up the ailerons. The objection here lies in the increase caused in landing speed.

Reasonable Stability

Now the next topic, that of reasonable stability, is best opened by referring to the requirements given out by the Guggenheim competition.

"The object of stability in normal flight is to demonstrate that the aircraft is stable under all normal flying conditions; that is to say, that if the attitude of the aircraft is disturbed, either by gusts or by the application of the controls, the aircraft shall return to its original attitude of its own accord when the controls are left free. The test of ability to recover from abnormal conditions has as its object to demonstrate the ability of the aircraft to recover from any attitude into which it may get either because of disturbances in the air or of incorrect application of the controls by the pilot or of sudden failure under difficult circumstances."

Pilots in the Air Mail have found stability a desirable feature. They have found, in bad weather, times when all their instruments seemed to move around, all spinning in different directions. If the pilot could let the machine go of its own accord and it would then assume a normal flying attitude, so that he could, for an instant, know just what the normal flying attitude was, they feel they could carry on; so they are very insistent on calling for an airplane that will inherently tend to attain the normal attitude. There are disadvantages, decidedly, to very stable machines. Very often they are stiff and loggy, and even uncomfortable. They are dangerous in cross-wind landings, if they have too much dihedral, but all this must be compromised in arriving at sufficient stability to bring out the quality desired.

Slow Landing Speed

Under another caption, slow landing speed, I should like to recall a remark made by an eminent aerodynamicist, in reply to a pilot's criticism of the dangers of low speed landing, that while it should be possible to walk away from a wreck, running into the side of a mountain at 35 miles per hour, it would be hopeless to expect doing it from one crashing at eighty to ninety miles per hour, as under the most favorable circumstances at present. In other words, if you are in very thick weather and can slow your machine down, still maintaining your altitude and control, even if you do hit something, your risk will be decidedly reduced. To the layman it is odd to hear that low-speed landing is dangerous, but in case of high winds, it could certainly be very dangerous. It is therefore advisable to have higher landing speed optional if possible. One criticism of slow landing speed is based on its calling for too light a wing loading, causing discomfort in gusty weather. I think this phase is a little bit over emphasized.

I would like to refer to the Guggenheim rules again. The object set in the rules for speed tests is "to demonstrate the ability of the aircraft to fly and glide at much lower speeds than is possible in the case of present day commercial aircraft, thus reducing the risk involved in negotiating forced landings and particularly under conditions of bad visibility and when approaching small and confined landing space."

Climbing and Gliding

The next consideration is that of climbing and gliding. It is very desirable, in a confined area, to get off in as short a run as possible with as high an angle of climb as possible—not necessarily rate of climb, the angle of climb is the important thing for getting over any obstruction. Of course, we don't want to be all day about it and use up our gasoline getting over it.

"The test for landing run given for this competition has for its object to demonstrate the ability of the air craft to effect a safe landing in a small field. The test of landing in a confined space has for its object to demonstrate that in case of complete engine failure, the aircraft can approach and land in a small, confined space, surrounded by obstructions such as trees, buildings, etc."

"Take Off—To demonstrate that the aircraft can take off from a small field and after taking off, climb at a steep angle over such obstructions as trees, buildings, and so forth."

Automatic and Stall Landings

Finally, we have miscellaneous features, such as maneuverability and taxi-ing on the ground. That leads us to a consideration of stall landings and automatic landings. The British, in 1923, made several experiments on automatic landings with a Vickers-Vimy commercial type cargo machine. It was lightly loaded and the gas was removed, except for what was necessary for the flight, so the center of gravity was located approximately one-third back of the leading edge of the wing; then it was trimmed for a tail-heavy condition. To attempt the automatic landing, the contrivance consisted of a 40-foot string with a weight of a pound and a quarter dangling at the end of it so that, when the pilot was coming near his airdome, the weight would eventually hit and give a signal to an observer in the front cockpit, who would then signal back to the pilot to release the controls. Under the given condition of trim, the machine should then land and stall itself to a very good landing automatically. It was actually found that the landings varied considerably; sometimes the machine leveled out above the ground, and sometimes it would have been below the ground, but in general, the machine got by with the test.

The idea of all that, is to bring out the difficulties involved and to start discussion on the subject of landing in a fog. The surface has only been scratched and certainly calls for a lot of research. Under any circumstances, any scheme of landing without controls depends on a definite constant trim of the airplane. In other words, you have got to know just where your center of gravity is going to be for landing, and the machine trimmed accordingly. Stall landings are possible at the present time, with some equipment we have, from heights up to twenty feet or so. The CO-4, of the Air Corps, equipped with an oleo gear has been landed in a stall from twenty feet. It happens to have sufficient tail surface to keep the tail down and not nose over. The limit is that deceleration we, as individuals, can stand, in other words, how much of a bounce we can take. Oleo landing gears certainly can be designed to dissipate any shock, but its limitations are found in the weight, the air resistance of a long stroke oleo gear, and the deceleration we can take from a short stroke gear. Mr. Roche, of our design organization at Dayton, took a ride down on a drop test of an oleo gear he had rigged up with a wheel and tire, to test the different strokes of oleo landing mechanisms. He dropped from a free height of 42 inches. He sat on this apparatus and found that 4g was about all he could stand. His recommendation was that local padding is more valuable than any kind of efficient oleo gears.

Other Related Problems

That takes in about all the questions of great importance in aerodynamics, but there are a number of others very closely related to them. Several years ago, a study was made of making machines for training much more safe. The control-stick was equipped with a lever which, when worked by the instructor, cut out the control-stick of the pupil. Very often pupils learning to fly get too excited at the wrong time; and it seems next to impossible to get them to loosen hold of the stick. That is a safety precaution.

Then this cockpit was equipped with big pads, that looked really like mattresses. These mattresses were held in by means of cables attached to something like one-way automobile snubbers, which gave way with a certain amount of friction. The pilot's seat was held back in the same manner. Thus, in case of a crash, everything moved forward a certain amount, in order to give its proportionate share, and lessen the chance of a real accident.

Windshields, giving proper protection and allowing a pilot to see, when he flies in bad weather, must be devised and used for military machines.

The reversible propeller has been used in reducing the length of run in landing, and also brakes. The reversible propeller, of course, depends on the engine, and if you have trouble with your engine, you can not use it. Brakes, however, have lately become of increased importance. The Army Air Corps has about 200 machines coming through equipped with brakes at the present time. It cuts down the length of landing roll to about one-third, but in taking off, all brakes can do is help get the tail up at the start.

In conclusion, it is evident that much can be done to adapt the conventional airplane to more safe aerodynamic requirements. There is also a much larger field hardly touched, called "unconventional," as typified by the autogiro.

Safe Flying from Pilot's Standpoint

By COLONEL CLARENCE. D. CHAMBERLIN

IT is pretty hard for me to make a speech even when I have something to say, but maybe I can say a few words on the subject—Safety from the pilot's viewpoint, or rather from my viewpoint, that is, of the plane itself, not so much its condition as its flying qualities. I want to run the aeroplane; I don't want it to run me, as too great a percentage of them do. Quite a little has already been said about the control of the plane at slow speeds. I was very sorry it rained this morning. I have a little plane over at the municipal airport that we can land in 100 to 150 feet, with very good control, that you can bring in at a very high angle, with a very small run. I may be able to show it some other time. The chief factor I like in a plane to be used flying particularly in small places, is a plane I can stall and hold it in a stall, and after I get it there, can make it almost sink in a good deal the order of a parachute. While I was over in England this last time, I had a chance to fly one of the new aileron controls, the de Haviland differential aileron control. One of the troubles in a stall is that a wing begins to drop and you pull the aileron cord to raise the wing, and instead of raising it, it pulls you around sideways, and then—it is too bad. Well, with this, or some similar method, there is practically no down movement of the ailerons at all. Instead of getting additional lift from the wing that is down, the aileron on the opposite side is raised, thus creating a drag on the side that is high and causing the other wing to go faster, and raise, in addition to spoiling the lift on the high side. I tried it out very thoroughly, because I was particularly interested in just that sort of thing. I got along very well in the army when we had a square mile to fly in and when Uncle Sam was paying the bills, but when I began flying my own plane around the country and had to pay for my own plane every time I crashed it up, I began to think of those things a little more.

The Constructor's Responsibility

The construction of the plane as it interests the pilot really depends on someone else making it strong enough, particularly where he is sitting. It is a very comfortable feeling, when you are flying along, to know you can stall your plane into almost any obstacle at a very slow speed, in fact, so slow you are almost certain of not being hurt. Some of the mail pilots, on the ships that have very low landing speeds, would prefer to go down with the ship rather than use their 'chute.

Another little thing in connection with that aileron control in a stall. The plane I flew over in England with this control was the DH Moth. It was the sweetest flying ship I have ever been in, in handling, with one exception, the Bellanca we flew across, even when loaded very heavily per square foot, would not stall suddenly. It had a wing curve where the maximum lift was over a period of several degrees, that is, if you are familiar with the characteristics of wing sections, the lift curve was flat for quite a long space at its top and then, in case of a stall or beyond its maximum lift, the lift would fall off gradually with the increase; which means that the wing will continue to lift at a very high angle, allowing stalling or squashing all the way. This particular ship, although I could do that with it, did have a tendency to yaw in a stall and didn't allow you to use the pull effect. We put a big rudder on it, and it almost did the trick; but some sort of aileron control, one of these schemes, would finish the job.

Visibility is always very important—seeing where you are going and what you are doing, in order to fly safely.

The Instruments

The location of the instruments is a matter not given nearly the attention it deserves. If you are going to fly in any sort of weather, you have to be able to read your instruments, or rather see the relation of all the needles without reading any individual one, if you are going to fly for long. We had our instruments strung all over the board, and while you watched one, another one would get off, and by the time you got that fixed, something else would be wrong.

The safety in our flight was in the ceiling of our ship. I had to do all the bad weather flying and also at night, and after about forty hours of it, it was beginning to get a little monotonous, and at one time we were able to fly—it was just off the coast of Newfoundland—we went up 15,000 feet with a good heavy load of gas. Well, it was our only salvation, largely because of the location of our instruments, spread from one side of the board to the other.

The stability of a ship is very important to a pilot that has to fly regular routes, through all sorts of weather. We were able to go two or three hundred miles and never touch the controls. That is very important in bad weather flying.

The instrument arrangement I prefer (almost everyone has his own ideas, so I imagine it is pretty hard for the constructors to please everyone)—I prefer all the directional instruments to be in a vertical line, and perhaps your altimeter and air speed in a horizontal line, so by merely looking at your instruments, you can know the relation of all of them without having to read each individual one.

Reserve Power

Reserve power is probably the next thing in safety, to be able to fly on at least half your power. I never had any fear particularly of our motor letting us down, unless water got into the carburetor. For instance, we took off very easily to about 2,000 feet, and immediately crowded the motor after leaving the end of the runway. I imagine most people think it was pretty hard on the engine, but as a matter of fact, we used only 10½ gallons of gas an hour as an average, which is an average of around 100 horsepower throughout the whole flight, or about 50 per cent of the power. I imagine water and dirt in the gasoline system account for a very large percentage of the forced landings. Most things, such as water traps, are usually placed in inconvenient places and the harder it is to get at them, the less attention they will receive. We arranged a handle in the cockpit by which in flight we could drain any water or dirt out of our water trap, and needless to say, every few hours it was drained.

Going back just a little to that reserve power, as a little example of what this particular ship would do, we were flying with a propeller that could turn 1,900 to 1,950 revolutions a minute, flying with full throttle, flying level. During the endurance flight we made last spring, we climbed 4,000 feet with the engine turning only 1,000 revolutions a minute. That meant we could lose three cylinders (our carburetor was arranged so that, in case of water or dirt, we could cut out three cylinders at a time)—if we lost three cylinders, that wouldn't have bothered us very much. If we lost six, we could still stall along until we could come to a field. That reserve in power will often get you over some bad country and into a field. It is very seldom a motor cuts out very suddenly. If it does, then you have to work fast.

Power Loading

I made just a little note on power loading because I heard something said about that. The maximum power loading we used was 27 pounds per horsepower. I figured only 200 horsepower, because at the take-off we had 1,750 revolutions per minute, which is in the neighborhood of not more than 200 horsepower.

In the next month or two, we expect to fly with over thirty pounds per horsepower because what we did was done on 27 pounds per horsepower, and very easily. However, for ordinary flying, down around 20 is much better, because then you have plenty of leeway, and if you lose a cylinder or two, you can still stay in the air till you get around to another field or get the plane in position to land.

The size of the landing field contributes an awful lot to safety. On an ordinary landing field, you can take-off and land perhaps a half dozen times before you come to the end of the field. Once you are up in the air, with a good plane that can glide a good distance, even if it necessary to stall it into trees in somebody's backyard, or any other place, there is very little danger, but there is a very critical time just after you leave the ground, and in case of flying out of small fields, if your motor fails immediately after take-off, you have no choice but to go ahead into whatever there is. So that is why we are always talking for large flying fields, even at the expense or necessity of going out some distance from town to get it. Your safety is in being able to get into the air and climb and get a little altitude, while you are still in a position to land in case it is necessary.

I am particulary interested in the small training planes, or sport planes, and in trying to embody these various characteristics in them to make them as foolproof as possible.

Colonel Lindbergh has done a wonderful work in the last few months, with the assistance of Mr. Guggenheim, in establishing all these municipal airports around the country. The next thing is to have them used. I think they are going to be used largely by local people, and if they can be used by local people and keep interest in the field, they will be enlarged and developed. But these people, particularly the younger fellows that are learning to fly, must have good, almost foolproof equipment, or there will be a lot of adverse publicity, and it will be rather hard on aviation.

As I said before, the flying qualities of the plane mean much more than the actual condition of the plane. Since the war, I sold 235 of what you would call junk airplanes, but to these 235 junk airplanes, which probably could not be licensed today, there has never been a fatal accident. The flying characteristics of the planes are responsible for that, the slow landing speed and good control, meaning safety for the passengers.

There is one little thing, not exactly on my subject, but which I think will interest you, the case of the younger people that are learning to fly. A few weeks ago, I was to give a ride to Guy Vaunce's son. A good many of you know him; he is general manager of the Wright Aeronautical. I started out to explain to him how the ailerons worked and the rudder, and he was very much disguested to think I should bother to tell him all these elementary things. Well, he had never been up in the air, so I said, "All right: we'll see if we can't take some of this out of you." So I took him up in the air, and the first thing I did was to have him take hold of the controls with me and work them so as to see how they operate and their effect. And then I thought I would give him a little kick, so I took my hands off and told him to go to it. And to my surprise, he did.

So I think it is going to be a good deal like the boys with the automobile. You know, there are very few of the boys nowadays you have to teach to drive a car. They grow up with it, and they watch you drive; until one day, if you won't show them how or let them take the car, they will steal it and go. I think they will pick up flying in a good deal the same way, and it will be made more possible as our planes are made more foolproof.

Safety in Air Transport Operations

By C. TOWNSEND LUDINGTON,

Chairman, Technical Committee, National Air Transport, Inc.

"HOW safe is flying?" "How soon will passengers be able to fly across the continent?" How often every air enthusiast is asked these two questions? If I knew the answers, I would be saved much lengthy explaining to non-air-minded persons! I think the only answer I can give is one I do not dare to give to the average questioner! Truly, flying is not safe! Neither is train travel, motoring, fox hunting, bank robbing or lying in bed. There is, in our daily lives, no such thing as being safe. What we are interested in, is the number of miles we can fly, the number of miles we can ride, the number of fences we can jump, the number of safes we can crack and the number of times we can seek rest in sleep before the law of averages gets us, in other words, "how long can we get away with it?" The conductor will assure an old lady that she is quite safe on the train, the motorist thinks nothing of starting on an all day trip, and the fox hunter will indignantly deny that he is taking great risks. Likewise the average pilot will tell his passengers that they are entirely safe. The intelligent aircraft operator, and his insurance man, know that such statements are not entirely true and, like the intelligent burglar, are interested only in knowing "how long they can get away with it." It is greatly to the credit of the operators, their pilots, their personnel, the designers of ships and engines, and the Department of Commerce, that they are today getting away with it for longer and longer periods between accidents.

The man in the street has today been educated up to the point of believing that the Air Mail has become pretty safe—and he is right—and he is just about beginning to wonder how soon he can ride too, when his sleepy eyes rest on the scare-head lines in his morning paper telling how some unfortunate pilot and his passengers met death when "the airplane suddenly nose dived into the ground." He shrugs his shoulders, decides the train and his "old bus" will do a bit longer and awaits developments. He doesn't stop to think that the accident occurred because someone "ran out of knowledge," and that aircraft operators today are acquiring greater stores of knowledge at a very rapid rate.

The safety problems of the operator of a fixed base concern are fairly simple. He must have a good field, good pilots, good mechanics, good shop equipment, and good ships; and he must confine his operations to good weather. The records show that responsible concerns of this type do very well.

The problems of the conscientious air transport operator are very much more difficult. In addition to the requirements I have mentioned, he must have good emergency fields, good aids and instruments, and his technical department must be constantly on its toes to take advantage of improvements in all branches of the art. His pilots must meet all weather conditions, for all the operator can do about good weather is to pray for it and all he can do about bad weather is see that as far as possible his pilots will be forewarned. The operator, or his board of directors, must decide whether or not passenger carrying is justified over his route and, if so, his problems are still more difficult. Ice and fog are his enemies and the Department of Commerce his best friend. Only if he has carried out all the latter's requirements and a great many more of his own, has the air transport operator a moral right to sleep at night!

I have assembled the figures of two representative American air transport operations. Those of the rest would not appreciably alter the story.

The Western Air Express carries mail, passengers, and express between Los Angeles and Salt Lake City. It has terminal fields and shops at these places, and one intermediate field. It flies over an airway, lit and maintained by the Department of Commerce. It crosses several high mountain ranges and long stretches of desert. It enjoys over most of its route a high percentage of good weather. Theoretically a daylight route, it has often to indulge in night flying as its west-bound plane can not leave Salt Lake until the arrival of the transcontinental mail plane, which is often delayed by impossible weather in the east. There are also occasional east-bound delays due mostly to morning fogs at Los Angeles, but these have never been serious enough to cause the mail to miss its Salt Lake connection. The flying and shop equipment is excellent and the entire operating personnel is of the highest class.

In the period from January first to August first of this year a total mileage of 306,597 miles was flown in 3,165 hours and no forced landings due to either weather or mechanical troubles were experienced. Over 123,000 pounds of mail were handled without loss and 269 passengers were carried. Compared with a possible perfect performance, the ontime record of this company during this period shows its operations to be 99.86% efficient. Since April 17th, 1926, when operations began, the Western Air Express has had some forced landings but no accidents of any sort, beyond three or four very minor claims under its workmen's compensation insurance.

National Air Transport, Inc. has a longer route, and more difficult and varied problems. Its ships fly between New York, Chicago and Dallas. They carry air mail and express. During the month of September, passengers were successfully carried on the Texas route but this practice has been discontinued. Weather conditions, for a good distance north of Dallas, are fair; nearing Chicago, they become poor; and over the Allegheny mountains. they are probably the worst in the United States. A day and a night service are run over this latter portion, and during much of the time, night flying is necessary at both ends of the Chicago-Dallas portion. From May 12th, 1926, to October 1st, 1927, 1,129,074 miles were scheduled to be flown. Of this total, 1,085,657 miles were actually flown in scheduled service. 43,417 miles of scheduled flying were defaulted, due to weather or other causes, giving an efficiency record of 96.1%. There have been 149 forced landings, of which 114 have been caused by weather, 33 by mechanical failures, and two by lack of gas. In only 46 cases, was it necessary to entrain the mail. There have been no physical injuries to personnel. The total repair bill, due to forced landings, would not exceed $9,000, though the equipment has an inventory value of nearly half a million. That statement, incidentally, leaves out any reference to the disastrous fire in the hangar at Kansas City, which, however, was heavily insured; fortunately!

During the month of September, a total of 237 passengers were carried, 195 on the Chicago-Dallas route and 42 on the Eastern route. The total passenger miles traveled was 85,861. This is too small a total to prove much as regards safety. Passenger carrying was discontinued, because of a slight defect in the lateral control of the ships used for the purpose, which might have led to a serious accident in the event of a landing in rough air. This is easily remedied, but it is not likely that the company will hasten to resume passenger business because of (first) the responsibility and (second) its not paying. During September, a grand total of 5,353 lbs. of express and 53,680 lbs. of mail were carried.

The flying and shop equipment of the N. A. T. are first class, and the personnel is splendid. A spirit of optimism prevails throughout the organization, combined with a feeling of responsibility in carrying on. A growing belief that the company "is in a business" is very evident. The job of the traffic department is obvious. That of the operating personnel is one of careful maintenance and strict vigilance.

The air lines have arrived to stay. Vigilance is enabling them to "get away with it," longer and longer between accidents. Radio beacons and other improvements will help immensely, but vigilance, knowledge, and system will always be the keynotes of safety in air transport.

EVENING SESSION

"Safety First"

HOLLINSHEAD N. TAYLOR,

Toastmaster

THE duty of the Toastmaster is a singularly easy and pleasant one this evening. It may, indeed, seem superfluous that there should be the duty of introducing the guests of honor and the speakers this evening; because they are known so well to practically all of the audience.

This has been a great year in aviation. Just about a year ago, the Engineers Club held a similar meeting on aviation, which was well attended, and served to sum up the accomplishments of aviation up to that time. The Club has seen fit to hold these meetings from time to time, to pause and take account of what has happened in the past twelve months, to mark a milestone, so to speak, in the progress of aviation.

This year we mark a very important milestone. The last year has been filled with the most extraordinary accomplishments and we are exceedingly fortunate in having here tonight several of the representatives of those great feats. Further, this particular week, in Philadelphia, is crowded with aviation interests. Beginning with this meeting of the Engineers Club and terminating, on Saturday, with Colonel Lindbergh's visit, in the course of four or five days, we shall have had here in Philadelphia, each of the three men who have successfully crossed the Atlantic.

The first speaker of the evening is a man who has not only made a name for himself high in the annals of aeronautics, but has also endeared himself to those of us in Philadelphia who have come in contact with him in his previous visits, by reason of his charming personal qualities. Commander Byrd, you may not know, had charge of the navigation plan for the first successful transatlantic flight in 1919. He also had many very difficult and delicate problems to work out in connection with the North Pole Arctic Expedition, and of course, on his recent transatlantic flight, he was again the navigator of the ship. So he is especially well qualified to talk to us tonight about safety in aviation from the standpoint of the aids that are given to the pilot on his instrument board. This, therefore, is a continuance—this evening's meeting is a continuance of the session this afternoon, which dealt with various other aspects of safety in aviation. The Club thought it wise to select this particular topic at this time because, while we have had a remarkable record of achievements in this past twelve months, there have also been a number of very distressing accidents, which have possibly shaken public confidence, to some extent, in the general use of the air, and so it seemed proper that we should stress what is being done to make flying safe. The various aspects of truly safe aviation are being treated in the course of the afternoon and evening sessions.

Avigation

By COMMANDER RICHARD E. BYRD

IT is, in my opinion, possible today, with the instruments available, to navigate an airplane, over long distances without landmarks, almost as accurately as a surface ship can be navigated. The airship has advantage over the surface ship, in that there are no submerged rocks for it to crash into. Even in a fog, a plane can be navigated accurately, with radio bearings and the radio beacon. Away from civilization, where no radio stations are within range, neither the surface ship nor the air craft can be navigated with any degree of certainty of hitting the mark. The surface ship can stop her engines and wait for the fog to clear, but the airplane must keep going, and when the fuel gives out, she cannot land in the thick fog, even if there is a smooth landing place underneath. That is where the surface ship has the advantage of the airplane.

Fog has always been, and still is, the greatest enemy to navigation, both on the surface and in the air, and it is such a big handicap to aviation that science must soon conquer it. It undoubtedly will be conquered. The radio beacon is a step in the right direction. This apparatus can keep the plane on the course, just as the compass does, and can guide the plane accurately to itself through any haze or weather conditions. When the plane is on its course, the radio operator receives two dots, we will say; when the plane goes off the course to the right, he will receive a dot and dash; and when off to the left, two dashes. Then, the radio operator can get lines of position from two different stations, and where these lines intersect, gets his fixed position. If he gets enough of these, he can tell how he is being drifted in the fog. That is the only possible way to obtain the drift of a plane, caused by the wind, when flying in a thick fog. Science has been striving for some years to develop an instrument that can be used on the plane itself to give wind drift, but so far as I know, has been entirely unsuccessful.

The pilot cannot make a navigator of himself over night. When he has to navigate over the sea, it is certainly a great advantage for him to know something about the sea. The idea got around that it would be an easy thing for a land pilot, without any knowledge of navigation, to fly over the hundreds of miles of ocean, and hit his objective. How many of those navigators who have been lost on the recent transatlantic flights made any real pretense at navigating? They simply followed their compass courses, and I am not sure how accurately the error was taken out of those compasses. I am afraid that some of the pilots who flew for Hawaii missed the Islands and went on beyond them.

Take Chamberlin's experience. He is one of the greatest pilots the country has produced. I heard him say, in a speech the other day, that he made no pretense at navigating on his transatlantic flight because he felt he could hardly miss Europe. At one stage of the flight, he decided to fly south to get around a storm. His plan was to fly until he could hit the ship lane and then change his course. He did strike a ship and took it for granted that he was in the ship lane, and then changed his course to fly to the northward again. Suppose that ship had not been in the ship lane! He says he did not know exactly where he was, but finally, he saw a big ship beneath him that had several stacks, so he knew it was an ocean liner. He flew down low and got the name of the ship; it was the "Mauretania." He had a copy of the *New York Times* with him; he pulled it out, looked up the sailing date of the "Mauretania," and calculated its probable location. Then he flew over the "Mauretania," in the opposite direction to that in which it was going, noted the compass course, and held on to that course. Now if the "Mauretania" had been temporarily headed off the course, he might have hit pretty far off.

I wish it were possible that transoceanic flyers might heed the warning not to fly without navigators. No man living, who simply flies along a compass course, can hit the mark if he gets in the clouds, and at the same time, encounters a strong cross-wind. Ruth Elder and Captain Haldeman made no real effort, as far as I can find out, to navigate. They got far off their course to the south, and had no idea where they were. With the proper radio and an airplane sextant, it would have been possible for them to get their approximate position. When their oil began to get low, they could have made the Azores, if they had headed for that point immediately upon discovering their difficulty. Steamers are few and far between on the ocean because it is a pretty big place, and if they had not met that steamer, there would have been one more mystery added to the already long list.

Maitland and Hegenberger, though they are not even web-footed, accomplished a perfect navigation performance. They were as certain of hitting their destination as a surface steamer would have been. They had a drift indicator, which gave the drift caused by the wind. They had a radio beacon at Hawaii to guide them on the course. They had an airplane sextant, and Hegenberger constantly obtained lines of position from the celestial bodies, and they had large bombs to drop on the water for use at night. Here is where the Navy must take its hat off to the Army.

I had all of these instruments on the North Pole flight, except that I was not able to get radio bearings and there was no radio beacon. Our compasses were no good and so we had to use a sun compass, which was invented especially for Arctic work. On that flight I spent at least one-third of my time watching the drift caused by the wind. I got a little snow-blind in one eye sighting so much on the snow. We had to fly out from a small island, strike a point in the middle of a frozen ocean ahead of us, and then be sure that we would hit that island on our return; because if we should miss it, there would be no chance of our getting back. That was why I took the drift so carefullly.

I hope that I may be pardoned for telling the navigation story of the transatlantic flight plane, "America." Until we left Newfoundland, we were able to obtain accurately the drift of the plane caused by the wind, by sighting through a trap door we had made in the bottom of the plane. It was not necessary to take radio bearings or astronomical observations, because we could see the land.

When we left Newfoundland, we ran into fog. And then for 2,000 miles, we saw neither land nor ocean. It was not possible to get the drift caused by the strong winds that were blowing at an altitude of approximately two miles. However, while lost in the clouds up in the cold 10,000 feet high, we were able to locate ourselves exactly by getting radio bearings from ships beneath us. We knew that the strong northwest winds were drifting us to the south and we knew how much. We set the course for Finistere, France, and then held on it, knowing all the time just where we were going to hit it. And that was after seeing no navigation mark of any kind for about 2,400 miles. We must give the credit for that to the radio operator on the flight, Lieut. Noville.

I thought we were going to hit Europe without even getting a sight of the ocean, but finally, not long before we struck France, we came out into some weather that was somewhat clear. I could even, without radio bearings, have located myself with astronomical observations. If it had been night, we had flares, which we could have dropped into the water, on which to sight to get the drift of the plane.

We flew from Brest, followed up the coast of France and knew exactly where we were, until we again ran into fog and stormy weather, as night came on. We set a course for Paris and I felt confident we were going to hit it. We had come many thoustands of miles and there were only a few hundred to go. It was quite an experience flying up there around in the dark. We couldn't see our hands before us, but of course we had electric lights that we could turn on when needed.

About the time we should have reached Paris, we came out of a rift in the fog and clouds, and I saw what I took to be a beacon ahead. I thought it was LeBourget. Imagine my surprise when I found out that that beacon was a lighthouse, and that, instead of being at LeBourget, we were somewhere on the coast. We had gone around in a circle. The vertical pointer, of the earth induction compass we were steering by, had stuck. The pilot's compass was expected to synchronize with the navigator's compass in the compartment aft. I had taken with us the regular ship's compass and we knocked on the dial of the earth induction compass, finally getting it with the ship's compass. We then set another course for Paris. We must have been very close to it because people there could hear our engines. But it was so thick we couldn't see the field.

We had reached a point beyond which I did not dare go, because if we should miss Paris, we would not have gasoline enough to get back to the water, and would have to make a forced landing over land in the dark, which would, of course, have ended disastrously, and might have injured some people beneath us. So I set a course for that lighthouse several hundred miles away and we managed to reach it. By its flashes, we could tell where the water was and where the shoreline began. We decided to land far enough from the beach to avoid hitting any rocks, and close enough to swim, in case we had to. I dropped three navigation flares in line, and although we couldn't see the water, we landed by them in the pitch dark. We must give Balchen credit for that landing. Without those navigation flares we would undoubtedly have crashed.

I understand that, since our flight, the French are putting up a radio beacon at LeBourget, and if some method is discovered, as I am sure it will be, of penetrating the fog, we could fly across the Atlantic, under conditions similar to ours, and land at LeBourget without any trouble.

Primary Policy of the Daniel Guggenheim Fund

By HARRY F. GUGGENHEIM,

President, The Daniel Guggenheim Fund for the Promotion of Aeronautics

THE development now taking place in aeronautics is going to make possible safe flights in the future. But I am very grateful that that development had not eventuated before this summer because, if it had, I think the youth of this country would have lost probably the greatest inspiration of the age, in the achievements of men like Byrd, Chamberlin, Lindbergh and others. We need never worry that America will sink in the mire of materialism as long as we have such spirits as these.

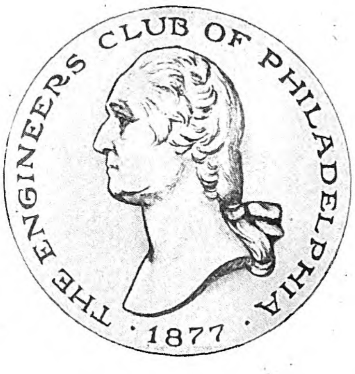
"I have personal confidence in the practicability of transporting passengers and goods, more surely by air than by water and land, with a velocity of from 20 to 100 miles an hour." That is a quotation from Sir George Caley, made in the early part of the 19th century. If Sir George Caley had been in Italy last month to witness the Schneider Cup Race, he might have chuckled to himself complacently at his modest prediction that aeroplanes might eventually travel between 20 and 100 miles per hour, and if he had been hard pressed about the other part of his prediction in regard to safety, he might very well have replied that he certainly had not included in his prediction stunt flying, reckless private flying, experimental flying, and military and naval aviation, whose dangers are the price we must pay for preparedness in time of war. Or perhaps Sir George Caley might have well said that aviation today, under proper conditions, is as safe as transport by sea; but I am rather inclined to believe he would have accepted the fact that it is not as safe, and he might have blamed us moderns for the fact that it is not.

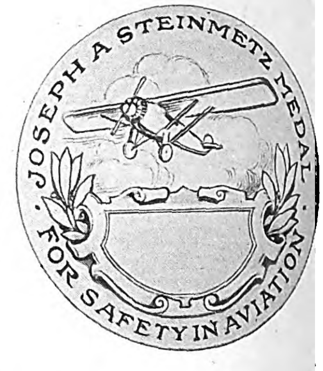
The war interrupted the normal development of the airplane and yet gave it a tremendous impetus. The requirements for war were mainly speed, maneuverability, and other similar characteristics. Those do not include the main requirement for peace. Safety is certainly the prime consideration in commercial aviation. In spite of the fact that we have made tremendous progress in the development of engines, in structural development, and in the development of instruments, safety has not been given the consideration it deserves. When the Daniel Guggenheim Fund for the Promotion of Aeronautics established its policy of safety, there were some in aeronautical circles who believed it was unwise to publicly proclaim the fact that we were developing that phase of aviation. They thought perhaps the mere mention of it might lose public confidence, but I don't believe there are many today, after the developments of this year, that still will cling to that thought. Last spring, in a paper I had the privilege of reading before the Society of Mechanical Engineers in Buffalo, I dwelt on that point, and I would like your permission to read a paragraph from that statement.

"The traditional taboo of the subject of safety probably can be traced to a desire on the part of aviation's early priesthood to protest against the existence of dangers which they had no means of overcoming. I can conceive of no more stupid policy than continuing this traditional silence, which has left the public so completely ignorant of the course of aviation that it grossly exaggerates these dangers, and ignores the elements of safety already attained. This misapprehension on the part of the public can not be overcome by any amount of shouting that aviation is perfectly safe; it must be overcome by giving the public a knowledge of aviation which they today so woefully lack; and one way to enlighten the public is through a full and frank discussion of everything about aviation, including its dangers and the manner in which they have been and are being overcome."

The results of this extraordinary season in flying which your Chairman so eloquently pictured, have aroused the public to tremendous enthusiasm, and now they are ready and anxious to know more about aviation and all of its phases. Very fortunately for the development of aviation, the subject is no longer in the hands of the aeronautical enthusiasts and the pioneers, who incidentally deserve so much credit for having had the vision and the patience, when they didn't have public enthusiasm to support them. But today aviation development is in the hands of the public and that is most fortunate for everyone in aviation. The public are demanding such discussions as it was my good fortune to hear today, and I want to take this opportunity to express my admiration for the officers of the societies who sponsored this meeting for having assembled, I think for the first time in America, these experts to discuss various phases of safety in aviation. I firmly believe it is the most important meeting that has ever been held, and I am sure that it will point the way to many more meetings of the same character. It is the most important meeting, because safety is undoubtedly the most important subject in aviation's development. The perfection of that development is awaited today by an enthusiastic but still a skeptical public.

The Joseph Steinmetz Medal for Safety in Aviation*


THE ENGINEERS CLUB OF PHILADELPHIA
1877



MR. HOLLINGSHEAD TAYLOR:

Here in Philadelphia, we have for a great many year, had an organization known as the Aero Club of Pennsylvania, which started 'way back in the days before flying was an accomplished fact, because I think it is now one of the oldest aviation organizations in the country.

For a great many years, the next speaker, Colonel Steinmetz, was the head of the organization, and for a long time he and a small group of enthusiasts endeavored to keep up some public interest in aviation in this locality.

He has done a public-spirited thing in establishing this award, which he will tell you about. We need just such encouragements as this to stimulate interest in this subject of safety. As an associate of Colonel Steinmetz, my old friend, I take a great deal of pleasure in introducing him to this assembly.

CONDITIONS

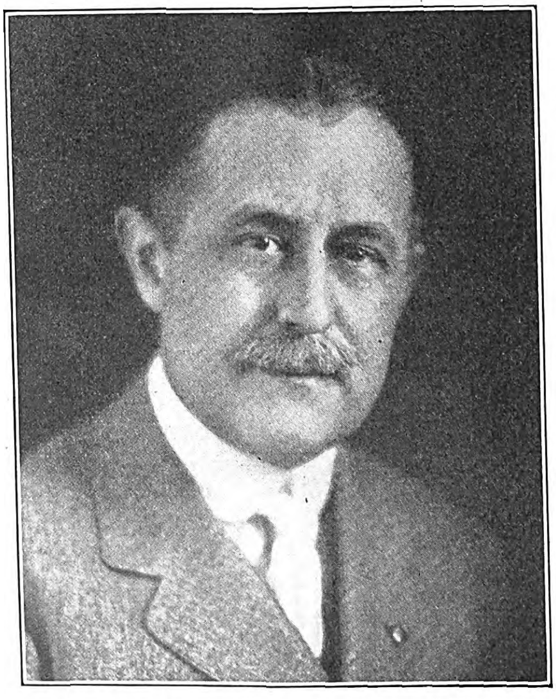
This Safety in Aviation Medal will be awarded, under the decision of a jury, to the individual or company developing, during the previous calendar year, a device or devices, or formulating a method contributing, in a pre-eminent degree, to safety in aviation.

The Jury will consist of three members, of whom one will be designated by the Chief of the Air Corps of the United States Army; one by the Chief of the Aeronautical Bureau of the United States Navy; and one selected from among engineers prominent in aviation, by the Engineers Club of Philadelphia.

The originator of any device or method, demonstrated to be worthy of recognition for its practical value in increasing safety in aviation, should be brought to the attention of the Jury on or before March 1st, with a brief description of the device or method and a statement that it has been completed during the previous calendar year.

The award of the medal will be announced and its presentation made by the Engineers Club at its Annual Aviation Meeting, held in October of each year.

It is a very little thing indeed announced on the program; simply this, that for years the Engineers Club has had aviation very much at heart, and we had a discussion sometime ago whether there might not be many serious men working on safety in aviation, who might be without a method of bringing their work to the public notice. So it was thought there were many opportunities for the expression by the Club of its encouragement, and it was with that hope this little gift was put up, as an annual trophy. Of course, after all, the greatest element of safety we can imagine in the airplane is a good pilot, and those here tonight have so shown their quality that it is really with great humility I ask the acceptance by the Club of this opportunity to be helpful to safety in aviation.



Col. Joseph A. Steinmetz, the Donor

ACCEPTANCE

Colonel J. A. Steinmetz,
Past President,
Engineers Club of Philadelphia,
Philadelphia, Pa.

Dear Colonel Steinmetz:

It is my pleasure to advise you that at the last meeting of the Board Directors of the Engineers Club of Philadelphia, your endowment of a fund for the purpose of annually awarding a medal to the person making the most recognized move in the cause of safety in aviation, was formally accepted with sincere appreciation.

Your gift will, we are confident, be the means of making great advancement in the cause of aviation and coming as it does, from a pioneer in this movement, it will be all the more conspicuous and of increased value.

Cordially yours,
CHAS. E. BILLIN,
Secretary.

December 1, 1927

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*Medal engraved by Davison, Philadelphia.

Aeronautical Safety

By COLONEL H. H. BLEE,

Senior Business Specialist, Dept. of Commerce,
Washington, D. C.

IT is a real pleasure to be here this evening as the personal representative of my Chief, the Honorable Wm. P. MacCracken, Jr., Assistant Secretary of Commerce for Aeronautics, and I am glad to have the opportunity of bringing to you his greetings, and of talking to you for a little while on the subject "Activities to Promote Safety in Aviation." I shall limit my remarks to a discussion of some of the activities of the Department of Commerce having to do with the promotion of safety in aviation.

The policy of the United States Government toward commercial aeronautics is to supervise and regulate the use of aircraft in commerce, thereby assuring airworthy aircraft and qualified pilots; to collect and disseminate constructive information on subjects having to do with commercial aeronautics; to foster the development of the art, through the medium of scientific research; and to extend to air navigation, aids comparable with those which have been enjoyed in increasing measure by marine navigation since the establishment of the first lighthouse in this country, in the year 1715, at the entrance to Boston Harbor, by the province of Massachusetts.

The subject of supervision and regulation of the use of aircraft in commerce, including the inspection and licensing of aircraft, the examination and licensing of pilots and mechanics, and the promulgation and enforcement of air traffic regulations, was covered very fully this afternoon by Major Young in his address and hence needs no further comment on my part.

The Department of Commerce realizes that the success of commercial aviation depends primarily upon the service the airplane can render in comparison with other means of transportation. The airplane must show definite advantages, such as greater speed, better travel connections, greater comfort and convenience, more scenic and more enjoyable mode of travel, and so forth, if it is to attract business. At the same time, it must meet the public demand for safety and reliability, and the charges made must be economical, in the light of the excellence of the service rendered. From the standpoint of air transport operation, it is absolutely necessary that the planes be operated over definitely established routes, on regular schedule, both day and night, and through all kinds and vicissitudes of weather. To this end, the United States Government, through the medium of the Department of Commerce, is establishing a system of national airways, extending from Coast to Coast and from the Great Lakes to the Gulf of Mexico. This system of airways is being provided with a number of extremely helpful aids to air navigation, which I shall outline very briefly.

First, we will consider the lighting of our national airways. At approximately ten-mile intervals throughout the length of the airways, are being installed what are known as standard revolving searchlight beacons,—great beacons throwing beams of light of several million candlepower and making six revolutions a minute. These beacons are mounted on fifty-foot galvanized steel towers, and are visible from the air, on clear nights, for distances of from 25 to 40 miles. At points where commercial current is available, the beacons are made absolutely automatic in their operation; that is, each beacon is provided with a simple instrument known as a sun switch, which at sunset, automatically turns on the current, lighting the light and starting the beacon revolving, and turns the current off again, the next morning at sunrise, when the instrument is again struck by the rays of the sun. At points where commercial current is not available, small engine-driven generating sets are installed. At these points the beacons are operated under the attention of caretakers on duty either whole or part time, depending on the location of the beacon. The source of light in each case is a specially constructed 1,000 watt incandescent lamp. In order to provide against the burn-out of these lamps and thus insure continuity of service, each beacon is equipped with a device known as an automatic lamp-changer which, in case a lamp burns out, automatically throws a new globe into focus and permits the service to go on without interruption.

At approximately thirty-mile intervals, throughout the length of the airways, are being established and equipped boundary lighted intermediate landing fields, with caretakers on duty throughout the day and night. These fields are so laid out as to afford at least two runways at approximately right angles to each other and preferably not less than 1800 feet long and 400 feet wide. At or near one corner of each field, is installed one of the standard revolving searchlight beacons, of the type just described. The boundaries of these fields are outlined, throughout the hours of the night, by a series of boundary lights placed on about 250-foot centers.

Passing from the lighting of the airways, we shall consider for a moment the charting of the airways, and mapping of the airports and landing fields. The work of charting the airways was started a number of years ago by the Army Air Corps and Corps of Engineers. This work is now being handled by the Coast and Geodetic Survey of the Department of Commerce, that bureau which has for so many years supplied our marine navigation charts. Air navigation charts c strip maps, as the pilots call them, are being issued covering the entire system of national airways. The work of mapping the airports and landing fields was also initiated by the Army Air Corps, but is now being handled by the Air Information Division of the Department of Commerce.

The United States Weather Bureau, under the provisions of the Air Commerce Act of 1926, is extending extremely helpful aid to air navigation, by sending out over the airways from port to port, several times a day, special weather information. This includes special bulletins of weather conditions throughout the airways; special short period local forecasts; general forecasts, covering conditions over large sections of the airways, for periods of from 12 to 24 hours; and also what are known as the special upper air reports—reports giving the direction and velocity of the wind from surface up through the range of altitudes ordinarily flown by commercial aircraft.

All of this weather information is sent out over the airways by means of a ground communication system. On the transcontinental route, radio is used almost exclusively; also on several of the branch lines. The other lines are still using the commercial services, both telephone and telegraph. It is hoped, however, that within the course of the next few years, sufficient appropriations will be available to permit equipping all of the national airways with a radio communication system. This system will operate under the Radio Division of the Bureau of Lighthouses and, in addition to transmitting the weather reports, will probably serve for reporting the departure and arrival of aircraft, and in general, for the dispatching of traffic, in a manner similar to that in use so many years on our railroad systems.

Another important aid to air navigation, one which has been mentioned so ably by Commander Byrd, is the radio beacon for guiding aircraft through fog, storm, or other conditions of poor visibility. The Bureau of Standards started work on this instrument a number of years ago, and with the co-operation of the Army and Navy Air Corps, has brought it to a state of very practical development, and it is hoped it will soon be ready for production. In fact, a number of our commercial air lines are now using the radio beacon with marked success.

Another radio development, and one which will go hand in hand with the radio beacon, is what might be termed the radio milepost—a development to assist the pilot who is flying under conditions of poor visibility in keeping track of his exact location on the airway. The radio milepost or radio marker, as it is called, is a special type of small sending station to be located at each of the thirty mile intermediate landing fields. It is planned that each station shall give off its own chracteristic signal; that is, repeat over and over again the number of its particular field. Thus, as the pilot flies his course, he hears repeated over his headphones the number of each field as he passes over it, and hence is able to keep very accurate track of the distance he has covered and his exact location.

Another development on which the Bureau of Standards is working and which is about ready for production, is the two-way radio telephone to permit direct telephonic communication between the airports and the planes in flight. Thus the pilots may receive from the ports special traffic instructions and weather information, and in turn, may report back the progress they have made on their routes and their probable time of arrival, etc.

Another instrument on which the Bureau of Standards is working is the radio field localizer, an instrument for marking out, for the pilot coming in for a landing in storm or fog, the unseen boundaries of the landing field. Work is also being done on the development of an instrument known as the radio capacity landing altimeter, an instrument to assist the pilot in making landings in fog, by giving him a direct indication of the height of his plane above the surface over which he is flying.

I will not stop to mention some of the other developments on hand at the Bureau of Standards, but will give you a few of the outstanding statistics of our national airway system. The mileage of national airways in use January 1, 1927, was 7,970 miles. There were at that time lighted, or in course of lighting, 3,427 miles. It is expected by June 30, 1928, to have a total lighted national airway mileage of 7,519 miles.

Lighthouses and other aids to marine navigation would be of very little value were there no ports or harbors in which the ships could anchor and find shelter, and were there no docks to which they could moor to load and unload their cargoes. The same is true in the case of air navigation. Airports are absolutely necessary to tie a system of airways together and make it complete and effective. According to the provisions of the Air Commerce Act of 1926, the responsibility for establishing and equipping airports rests directly with the municipalities themselves. It stands to reason that, other things being equal, those cities having the foresight to establish and equip carefully designed, well located airports, affording the necessary facilities for safe and efficient day and night operation of aircraft, and with provision for expansion to meet the rapidly increasing needs of commercial aeronautics, will naturally be the ones to attract air commerce and the accompanying industries; and these will profit by their foresight.

Just a word with regard to the reliability and safety of air travel. Hardly a week passes that I am not asked the following three questions: How reliable is our regular scheduled air transport service? How much air mail is lost? How safe is it to travel on our air lines? To answer these questions I will turn to the reports of the Post Office Department, covering the government operated air mail lines for the past few years. During this period the air mail service, with its scheduled day and night operations on the transcontinental route and its night operations on the New York-Chicago over-night route, flying its planes through all kinds of weather, made approximately 96 per cent of all scheduled flights. Answering the question as to how much air mail is lost, records of the Post Office Department show that the percentage of air mail lost is even lower than that of registered mail sent by train. Referring to the question of safety of travel on the air lines, during the year 1926 the United States Air Mail Service flew 2,292,263 miles per fatality.

Such great strides have been made in the development and perfection of the airplane and airplane engine, in methods of operation and maintenance, and in aids to air navigation, that today the airplane stands out as one of man's greatest achievements in the field of transportation. And now, with the Federal Government extending to air navigation aids comparable with those extended to marine navigation for over two hundred years, the time is not far distant when the length and breadth of the United States shall be served by a network of highly developed and highly efficient commercial air lines.

Commercial Aviation

By CAPT. EMORY S. LAND, U. S. N.,

Assistant Chief, Bureau of Aeronautics, Navy Dept.

IT is of interest to record that America is the first country ever to send out a specification for a military airplane. As I recollect, this was written on two fool's-cap pages and is a unique contribution to the art.

Major fundamentals, such as speed, safety, reliability, and economy are the same in both commercial and military aviation. Differences begin to appear, in material, personnel, and methods of operation, at a later stage in the development of the equipment. Commercial and military aviation should form an interlocking directorate — not, however, in conflict with the Sherman anti-trust law. The science and the art of the two go hand in hand. In many ways and in many particulars they may readily be treated as the Siamese twins. Commercial and military aviation, once considered by the world at large as "The Babes in the Woods," have now developed at least to the status of "The Gold Dust Twins."

As a general rule, it is not practicable or advisable to combine military and civil functions in one design. Nevertheless, methods of design and construction for military services are frequently suitable for commercial purposes. This is true because many of the elements entering into the designer's work are independent of the use for which the finished machine is built. Progress grows out of knowledge; therefore, procedures that suggest to the designer means for improving the performance of military machines, should point the way toward the production of safer, more comfortable, more efficient, and more reliable commercial planes.

Probably it has been in the experimental field that naval and military aviation have been of more use to commercial aviation than in any other. The preparation of design data and of specifications; the factors of safety required; and the results to be obtained from elaborate tests in wind tunnels, model basins, and other experimental laboratories, have given data to the commercial aviation world that it was not in position to obtain for itself. This, of course, is because experimental data cost a tremendous amount and, so far as aviation is concerned, only the military services, backed by the Government, have been in a position to carry out this work. As examples of the places where this work has been done, one need only to look toward the Engineering Division of the Army Air Corps, at Wright Field; the Naval Aircraft Factory and the Aeronautical Engine Laboratory, at Philadelphia; the Wind Tunnel and Model Basins, under the Bureau of Aeronautics, in Washington; and the Laboratory of the National Advisory Committee for Aeronautics, at Langley Field.

One is often asked what value racing plane development has for aeronautics. Without going into details, it is believed this is one of the most important activities for the development of both commercial and military aviation. The racing plane of today is the fighting plane of tomorrow. Certainly, the development of racing planes finds a parallel in the automotive trade, for racing automobiles did much for the art and science of automotive development.

It does not require a wide stretch of the imagination to picture the conversion of passenger planes into transports, ambulance planes, or special military freight-carrying aircraft. We have seen, under our very noses, the utilization of observation planes as Air Mail planes. The latest Air Mail plane would make a reasonably satisfactory observation plane for many military uses. One extract from an official Army report is sufficient to put across the ideal. "The presence of commercial aircraft in the Hawaiian Islands, in reasonable quantities, operating for the transportation of passengers or express on inter-island airways, would be a distinct and invaluable asset to the Army in emergency defense of the territory; planes of this type being readily adaptable for bombardment mission." It is quite conceivable that, in emergency, a number of types of sport planes, two-place passenger planes, and, in general, planes used commonly about the country today, would serve a useful purpose as temporary training planes.

I do not wish to be understood as saying that commercial planes of all types can be readily adapted to military uses, for such is not the case. They would at best fill a stop-gap only. There are many similarities, but on the other hand, there are very marked differences, and we must in no respect, be carried away with the idea that a large number of commercial aircraft would be a proper force for military defence of the country. Furthermore, there are more radical peculiarities in planes suitable for strictly naval purposes than there are in any other type of plane, either military or commercial. For example, naval planes are nearly always convertible, that is, capable of being mounted on wheels for land use and on pontoons for water use. Naval planes are required to be catapulted, and must have special fittings and special strength for this purpose. A large number of naval planes must be capable of being arrested in limited space such as on a carrier. This requires special strength, special fittings, special reinforcements, and special factors of safety. Naval planes are always face to face with their own enemy, corrosion, and it is no exaggeration to say that salt water is one of the greatest enemies of Naval Aviation. Naval planes are frequently exposed to wind and wave, while other planes may be carefully housed in a hangar. It will therefore be evident to you that Naval Aviation conditions are much more severe than those of other service.

In 1667, Sir Walter Raleigh wrote, "Whosoever commands the sea, commands trade; whosoever commands the trade of the world, commands the riches of the world; and consequently, the world itself." Is there not a lesson for us in this quotation? In order to be effective, the Navy must be in position to assert itself in the air, on the sea, and under the sea. The increasing importance of aerial preparedness, as evidenced by the development of aircraft for military and naval operations throughout the world, must not find us laggard in maintaining the Navy at a high standard of efficiency.

Commercial aviation has made much history during the past few months, and there is a direct analogy between the relations of commercial aviation and military aviation on the one hand and the merchant marine and a "three-surface" Navy on the other. Many of the outstanding features, in the rapid development of commercial aviation in this country, may be attributed to the experimental work and service experience of Military Aviation.

Ten outstanding summer developments in aviation are:

(1) Lindbergh is not only an excellent flyer, but also an ambassador extraordinary, and the finest type of young American citizen plenipotentiary.

(2) The aircooled engine, developed with the cooperation of Naval Aviation, has proven itself.

(3) The Atlantic and Pacific Oceans can be crossed by airplanes, but not with impunity.

(4) The proper sphere of action for a land plane is over the land, and the proper sphere of action for a seaplane is over the water.

(5) The greatest desirability of amphibian types has been demonstrated.

(6) Pioneering in any field is expensive in lives and material.

(7) A spirit of aviation has been aroused in the American people, and a certain amount of knowledge has been absorbed.

(8) The American people are becoming more airminded, the practical evidence being the comparatively rapid development of landing fields and airports throughout the country.

(9) "Stunt-flying" for stunt-flying's sake is a poor business.

(10) Aviation is bound to be a vitally important item not only to American commerce but also to American national defense.

Lights and Signs on Gas Holders to Guide Night Flights

The use of gas holders as land guides for aviators has received the official approval of the American Gas Association. More than 1,500 gas companies are prepared to mark their holders, numbering 2,500, with arrows, or other suitable direction signs, following the lead already set by several companies.

Since the top of the holder is a large area of unobstructed steel, the signs will be ideal. Already tests have been conducted, and the signs are easy to read at an altitude of 2,500 feet, and under good flying conditions can be read without trouble at 10,000 feet. Doubtless the tops of the holders will be illuminated at night.

Gas companies will in all probability follow the specifications laid down by the U. S. Department of Commerce, according to Oscar H. Fogg, vice-president of the Consolidated Gas Company of New York, and president of the Association.

"The official colors will be orange on a black background," Mr. Fogg says. "All letters are to be in block design and one-third larger in height than in width."

The Application of Insecticides by Airplane

By IRWIN E. AUERBACH,

Secretary, Huff Daland Dusters, Inc., Monroe, Louisiana

THE history of crop dusting began in 1921, when airplanes of the United States Army were utilized in throwing insecticide over the side of the plane to dust catalpa trees, in Ohio, which were heavily infested with caterpillars. Learning of this work, Dr. B. R. Coad, of the Bureau of Entomology of the United States Department of Agriculture, in charge of the Delta Laboratory at Tallulah, Louisiana, and for years leader of the fight against the cotton boll weevil and the army worm, conducted extensive experiments, with obsolescent army airplanes and improvised hoppers, on the distribution of calcium arsenate to combat these insect pests. The equipment was limited to a dust load of from 200 to 250 pounds and required two men to operate, but showed sufficient promise to warrant a very much more careful study.

Huff Daland and Company, now, the Keystone Aircraft Corporation of Bristol, Pa., were invited to develop especially designed dusting airplanes, in conjunction with the Department of Agriculture. Great improvements in design were effected, and two types of plane, capable of carrying dust loads of 750 and 1500 pounds, respectively, were developed.

At first it was thought that individual planters, owning large plantations, would buy and operate their own planes, but even a cursory investigation showed that this was both impracticable and, likely, very expensive. It was found that a service company, which would furnish all the personnel and material used in dusting and which specialized in this work, could lift the entire problem from the shoulders of the planter and, at the same time, work much more efficiently and at less cost than if the planter attempted to own and operate planes himself. In this work, reliability of service is the outstanding necessity, for the pests do not wait, and the damage they can do in a short time is very large. Therefore, a large company, having reserves of pilots, planes, and motors, is in a unique position to dust under any and all conditions.

Dusting is in some ways the most hazardous and trying of all airplane operations. The airplanes are flown from 80 to 100 miles an hour and from 4 to 20 feet from the ground; sometimes the wheels may be seen rolling in the cotton. Naturally, airplane dusting is incomparably faster than any other method and the 200-mile-an-hour wind, which breaks the dust into a veritable foggy cloud, does more effective work, by far, than the slow, cart-driven, two- and three-row dusters previously used.

Since it was determined that the service company was the best way to meet the dusting problem, the Huff Daland Dusters, Inc., was organized and started operations in the spring of 1925 with a fleet of twenty airplanes. At the time, this fleet was the largest unsubsidized fleet of airplanes in the world and, today, it ranks among the largest commercial operations to be found anywhere. Equipment was designed to meet the most rigid Army and Navy specifications, as to factors of safety and all other details, and the Wright, J-4, aircooled motor was chosen as the most reliable power plant obtainable. Since that time, this motor has achieved universal acclaim through the flights of Lindbergh and others. The dusting operations of this company have covered the cotton belt from North Carolina to California, and they have operated in Mexico and, also, in Peru. Airplane dusting, when conducted under proper entomological advice, was recognized as a national asset to such an extent by the Government of Peru that special laws were passed allowing the equipment to enter without paying duties or customs of any description and, also, by granting the company a ten-year monopoly as an inducement to introduce this method of increasing the value of the cotton crop.

When it is realized that, if only one boll per hill, or if you like, one boll per running foot, is saved from insect devastation, with cotton 25 per cent below the present quotations, there will be a margin of profit after paying for five dustings, it is clear that the planter has much to gain and that the banker, who makes loans to the planter so that he may properly protect his cotton crop, is availing himself of the only feasible means of crop insurance yet developed. The most conservative figures will show that, taking a ten-year average, for an investment of from five to six dollars in dusting service, a return may be expected of from twenty to twenty-five dollars, depending upon weather conditions and the degree of infestation.

A curious comparison was made by one of the largest plantation owners of the Republic of Peru between airplane dusting and the method previously in use. Before the airplanes, special crews of mountain Indians were imported from the hills, who lived on the cotton plantations during the dusting season.

These men were each equipped with a bag, similar to a knapsack, and with a hand gun, which sprayed the calcium arsenate onto the cotton. They would be lined up just outside the field, with spaces between them, and then at the given signal, would start through the cotton, which reached over their heads. An hour later, perhaps, they would emerge at the other end of the cotton field with their sacks empty, and with no one knowing whether they had dumped the contents all in one place or made an even distribution. It has been reckoned that one airplane has replaced more than one thousand of these Indians and, even including in the comparison other methods used in the United States, it is interesting to note that this is the first time anything like 200 horsepower per individual has been used in agriculture.

Although many people think that cotton is the only crop that may be dusted by airplane, this is only because the first work was done on cotton. Over three hundred thousand peach trees in Georgia, pecan orchards, grapes, cantaloupes, peas and tomatoes have all been dusted by this company, and the dusting of sugar cane against the sugar cane borer has been attempted. This latter work, which was conducted co-operatively with the Louisiana State University, gives splendid promise of a very material saving to the sugar cane planter. The experiments, which have now reached a plantation-wide stage, were conducted by Dr. W. E. Hinds, assisted by Dr. Spencer, both of the Louisiana State University, and were begun in 1925 and have been increased in scope ever since. This year the Federal Government is spending more than fifty thousand dollars to determine the most practical methods for commercial use.

In fighting the cotton boll weevil, from three to five applications of from five to seven pounds of calcium arsenate per acre are usually required. The first three applications, given at five-day intervals, result in a practical extermination of the boll weevil on the acreage dusted, until the period of migration, when the weevils move in from the surrounding territory. Then the fight has to be renewed, until such time as the cotton has opened and the insects can do no further damage. Formerly, the poison was applied either from a sack jolted on the end of a stick by a man riding on a mule, or else, by a little high-wheel cart which left its little trail of dust on the plants. All dusting was done at night by the flare of gasoline torches, as it was necessary to utilize the dew in making the poison stick but, with the use of the airplane, night work is eliminated, for the propellor blast induces in the poison a positive charge of static electricity which causes it to adhere to the negatively charged cotton plant in dry weather as well as moist. The only limiting factor is a high wind which, of course, would blow the dust away. Thus, the best times for dusting are early in the morning, from sunrise to, perhaps, ten o'clock, and late in the evening, from, perhaps, five o'clock until sundown.

It is dramatic to see the airplanes swoop down over some trees into the cotton field, sweep across in a few seconds, and zoom out at the other end, leaving behind a white, fogged, poison cloud and making a swath of from 200 to 300 feet in width. This cloud hangs in the air from ten to twenty minutes before slowly settling in perfect coverage on all of the foliage of the cotton plant. Neither the weevil nor the worm has the slightest chance of fighting after taking in the poison. [See picture on cover of this number.]

Boulder Canyon Dam Bill

With the object of reducing the question to understandable terms, the Joint Committee of National Utility Associations has issued two publications relating to the Swing-Johnson Bill which was defeated in the last session of Congress and is scheduled to come up for consideration at the forthcoming session. One is a booklet entitled "The Boulder Canyon Dam," and is an analysis of the Los Angeles water and power measure, as the Swing-Johnson Bill is known in California. The other, entitled "Boulder Dam," is a comprehensive compilation of essential data which has been assembled by governmental and other authoritative agencies.

The larger volume contains five government charts illustrating how it is proposed to construct a dam 550 feet high in Boulder Canyon on the Colorado River with the main object of controlling the floods of the Colorado and irrigating Imperial Valley.

Welded Construction for Buildings

The use of welding as a means of construction of factory and other plant buildings is to be adopted by the General Electric Company in future building programs. The reason given for this policy is the fact that a study of structural design has shown conclusively that the welded structure can be made with less material than the riveted structure for the same loads.

The Company feels that its experience with welding indicates conclusively that, as soon as shop methods are developed, it will be possible to fabricate buildings by the use of welded joints cheaper than they can be fabricated by the use of riveted joints. There is no conflict between welding and riveting at the preesnt time, each having its own sphere will continue to be used. The feeling is, however, that, as welding becomes cheaper than riveting, it will supplant it.

General Aspect of Commercial Aviation*

By R. HARLAND HORTON,
Former Director, Air Transport Survey, Department of Commerce
Vice-President, P. R. T. Air Service

IT is within very recent years that we in the United States have been seriously giving any attention to commercial aviation. Flying has been more of a dream and less of a vision. The reference to flight in the classics of prose and poetry have been numerous, possibly because this flying through the air has more of a romantic appeal than our now more common modes of transportation. Jules Verne's "Trip to the Moon" had a far more romantic appeal than his "Thousand Leagues under the Sea." Naturally, one derives a greater inspiration through being projected through space in the blue heavens than from crawling on the bottom of the sea like a low-caste water animal. Therefore, of the methods of the most romantic of professions, transportation, flying has had the greatest romance. Many have been the experiments, many have been the dreams, and much the ground covered, from the first balloon ascension by Joseph and Stephen Montgolfier in 1783, up to the first definitely tangible results in actual flying, which were attained at Kitty Hawk by the Wright Brothers, of everlasting fame. Wilbur and Orville Wright generously gave great praise and recognition to Octave Chanute, styling him the "Father of Aviation;" it should be of particular interest to this body that Chanute was fundamentally a railroad man and in 1875 published a report recommending the construction of elevated railroads in New York.

Up until the war, experiments were numerous, and considerable progress had been made by enthusiasts, and then, during the war, tremendous impetus was given to development and experimentation, because of the great military value of the airplane. America was a leader in aeronautic experiment, and during our comparatively brief period in the war, we had every reason to feel proud of our personnel; the more so as we were sadly lacking in material, due largely to our unpreparedness and lack of organization, and not to lack of resourcefulness or ability by our manufacturers. The four-hundred horsepower Liberty motor was an outstanding accomplishment at that time, but nine years' development has been so rapid that the Liberty motor is now practically obsolete. The Army has developed some excellent new equipment, but of all the airplanes in the United States Army, few are equipped with modern engines; almost all have Liberty engines. Further than that, the War Department has in storage about 12,000 Liberty engines that have never been used. This surplus of engines, which has been carried over from the war and from which engines have been sold to whomever might care to purchase them at a fraction of their cost, has been one of the greatest hindrances to the proper development of aircraft motive power and one of the greatest handicaps with which the motor manufacturing companies have had to cope. With a tremendous supply of a cheap product on hand, quantity production of improved models is almost impossible, and consequently, prices on these are kept at a high point. One of the greatest benefits to aviation in general, one of the greatest aids our Government could give to this infant industry, would be to scrap and utterly destroy beyond redemption the entire remaining stock of Liberty engines, or in some other way to get them off the market. How many lives they have cost we do not know; on this score alone, I believe their destruction is justified. Their excessive cost of maintenance and fuel consumption is another indictment that would justify the death penalty. Do not misunderstand me from this condemnation of the Liberty engine; it was the best at the time it was developed, and many valuable improvements have been added since that time; with attention, it will give good service, but at the present date, it is thoroughly obsolete, and I am sure you will agree with me that it is a crime and a shame that the majority of our fighting aircraft should be equipped with antique and obsolete motive power.

However, some good did come from the surplus of aircraft at the conclusion of the war, not only in the United States, but in Europe as well. The experience gained in the carrying of mail, messages, and personnel, by air during the war, was very probably the cause of the inauguration, in Europe in 1919, of an airway system, which has developed tremendously in the ensuing years, so that, at the present time, central Europe is covered with a net of airways that extends into Africa and Asia and that shortly will reach to the far corners of the world. A great passenger and express business has been developed, in addition to the air mail. Foreign governments have seen the wisdom of developing air commerce and have supported these routes by generous subsidies, amounting to very substantial sums, though, many of the routes, without any commercial basis, merely serve colonial possessions for other reasons best known to the state and military authorities. European operations are so far ahead of ours that there is no comparison. They started, as have we, to develop air mail, but they soon learned that other services must be considered. While we continue to bend our energies towards development of mail transportation, the combined services of England, France, Germany, Italy and Holland, in 1926, flew almost 9 million miles, and carried 102,000 passengers and almost 10 million pounds of express, in addition to nearly 3 million pounds of mail.

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*Paper read before the American Electric Railway Association at Cleveland, O.

Prior to the World War, there were no commercial air routes in the United States, except some short lines operated seasonally, or occasional few-day demonstrations by private owners, in co-operation with the Post Office Department. In 1918, however, a real start was made, and an experimental air mail route was inaugurated between New York and Washington. It was equipped with military planes, and operated with military personnel. It continued for a while and then was discontinued. Its operation, however, was the basis for the idea of the Transcontinental Air Mail route between New York, Chicago and San Francisco.

Operations actually started between Cleveland and Chicago on May 15, 1919, and on July 1, were extended to New York from Cleveland. On May 15, 1920, the line was extended west from Chicago to Omaha, and on September 8, in the same year, mail carrying began between Omaha and San Francisco, by combination daylight airplane and night train service. That is, the letter was flown out of New York, put on a train in the evening at Chicago, taken off the train the following morning, and flown the rest of the route the next day. Another route, from St. Louis to Minneapolis-St. Paul, was operated by the Post Office Department between December 1, 1920, and June 30, 1921.

The first private contract routes were those operated between Seattle and Victoria in the northwest and between Key West and Havana in the southeast. The Seattle-Victoria route is still operating and is used largely for expediting mail carried by trans-Pacific steamers. The Florida route, however, was discontinued March 31, 1923.

A similar service began operation April 9, 1923, between New Orleans and Pilot Town. Another comparatively short route, but important in the matter of time saving, operated in Alaska five months in 1924, between the towns of Fairbanks and McGrath. The mail, previous to this, was carried by dog-teams. Beginning July 1, 1924, night flying began between Chicago and Cheyenne, this portion of the route having been lighted by the Post Office Department, and from this date on, all rail transportation in connection with the air mail was eliminated. Subsequently, lights were added between Chicago and New York on the east, and Cheyenne and Salt Lake City on the west.

At the start, the mail carried on the Transcontinental Air Mail System was not of any particular class, but any first class mail the Department felt could be expedited by such transportation. Later, the Post Office Department instituted a definite air mail service. Then, the air mail route was divided into zones, the postage rates being eight cents per ounce per zone. The Post Office Department also let out air mail contracts at rates not exceeding three dollars per pound for units of flight of 1,000 miles or less. Following this, the system of air mail routes has been established. Routes that would act as feeders to the Transcontinental route were first developed. On July 1 of this year, the Post Office Department transferred to private contractors, operation of the Transcontinental route between Chicago and San Francisco. On September 1, private contractors took over the service between Chicago and New York. During this period, there has been developed an air mail system consisting of one main trunk line through New York, Cleveland, Chicago, Omaha, Cheyenne, Salt Lake City and San Francisco with feeders to and from Boston, St. Louis, Dallas, Minneapolis-St. Paul, Detroit, Pueblo (which is the service to Denver), Los Angeles, and Pasco, Washington, (which serves Portland and Seattle). Independent of the Transcontinental route, is the service between Los Agneles, San Francisco, Portland and Seattle. These many feeder routes, with a postage rate of 10 cents per ounce, and the Transcontinental zone rate of eight cents, with the addition of the overnight mail between New York and Chicago, which cost ten cents, brought about a confusing condition, wherein it took a sheet of paper of larger than letter size, printed in fairly fine type, to list the air mail rates between the various points in the United States. Because of this, in the spring of 1927, the Post Office Department instituted a new ruling, abolishing the zones and establishing a rate of 10 cents per ½ ounce, between any two points in the United States, in which air mail might be of service, and regardless of the number of zones or air mail routes used. This was a step in the right direction. In spite of it, our air mail contractors have been existing under conditions which might be called precarious, and what the future has in store for them in a subject for grave speculation. You will remember, in the earlier days the postage rate was ten cents per ounce, per zone or per line used. Letters generally run about forty to the pound and the Government's revenue was about $4.00 per pound and the contractor received not more than $3.00. Obviously, the Post Office Department received its full two cents per letter for collection and delivery, and a little bit more, and the contractor had the full burden of developing the air mail. The Post Office Department, with the exception of the Transcontinental Line, has not risked a nickel. What the financial results have been and will be under this new rate, we cannot determine yet, and it is doubtful if we ever can. However, it has served to materially increase the volume of mail, which is the contractor's greatest need.

In my opinion, the method of compensating the air mail contractor, and the air mail postage rate, are open to very great criticism. In the first place, the air mail postage rate is entirely too high to induce a large volume of mail. Provided a proper method of compensation is devised for the air mail contractor, the postage rates can be reduced to as low as five cents per ounce, in addition to the normal two cents, and stand a good show of making air mail pay its way, certainly without involving a deficit as great as many other departments of the Post Office are incurring. From the figures made public by the Post Office Department, simple arithmetic shows the earnings of air mail contractors, and exposes a few of the fallacies of the present method of compensation. In the first place, does it not appear to you as a rather unpromising method of developing this new agency of transport to encourage the establishment of air lines for the carriage of mail alone? And further, does it not seem rather a hardship on such a new and venturesome enterprise to require that the air mail contract be let by competitive bidding? Would it not be more just to reward an established air transport carrier, in business for the carrying of passengers, mail or express, that is, a company actually in the transportation business, with the privilege of carrying the air mail along its routes? It should be recognized, as the Post Office Department does now with the railroads, that the mere fact a trip is made is of value, whether there be 5 pounds or 500 pounds of mail carried on that trip. The railroads are recompensed on the basis of space reserved for mail matter and the miles that space travels. Air transport companies are paid by the pound, regardless of the amount of space reserved, and regardless of the distance it travels, up to 1,000 miles. That is, the Colonial Air Transport receives $3.00 per pound of mail it carries 220 miles, from Boston to New York; and the Western Air Express is paid precisely the same amount for each pound of mail it carries 600 miles, from Los Angeles to Salt Lake City. The argument for this method is that, since the short hop is not of a great value to the air mail, the volume, and hence the compensation is less. True enough, or rather, too true! Although this line is an important feeder to the Transcontinental line, it received, for the first six months in 1927, a little more than $24,000 for flying a total distance of 53,000 miles, or a little more than forty cents a mile, while the Western Air Express received about $267,000 for flying 205,000 miles or about $1.30 per mile. In the first case, the amount is substantially less than the cost of operation, and in the second, is a very substantial amount above that cost. My congratulations go to the Western Air Express for picking this 600-mile route, with its heavy traffic. Congratulations are also in order for at least two other contractors, but to the remaining ten contractors, I have nothing to offer but my deepest sympathy. They are flying their routes and flying them well. They are making a trip daily, regardless of the quantity of mail carried, and the mail carried may and does fluctuate tremendously. Theirs is the hardship whether or not air mail is developed, although theirs should not be the burden of developing it. Times without number have these air mail contractors flown from Chicago, Cleveland, or other connecting points, without mail, and received no compensation, although they stood by, ready to serve, and were subject to penalties if they were not ready to serve. There was no mail, not because of any dereliction on their part, but because either the Transcontinental route was weatherbound, or for some other reason, that mail did not arrive, up to when it was necessary for them to leave, in order to make their trip from the other end of the line on schedule. Such a condition is neither fair nor just nor economic, and I cannot see how it is possible for air transportation to develop and grow as it should, until some recognition is given to the readiness-to-serve element, the terminal costs, and the mileage costs. These criticisms have been made in a spirit of constructive suggestion and with a desire to forward the development of air transport under proper economic principles.

The extent to which the air mail has developed, in spite of the foregoing, is, however, impressive, and a few statistics along this line may not be out of place. During the first six months of 1927, there were flown more than 2½ million miles, to carry more than 600,000 pounds of mail, and this performance is worthy of much admiration. By the private air mail contractors, about 4,500 trips were scheduled, 4,100 completed, and 147 were not started. By the entire service about 5,200 trips were scheduled, and 685 were either not started or not completed, for the following causes:

Weather conditions	623
Shortage of equipment	30
Structural	4
Mechanical	28

This is a forceful demonstration that the perils of air navigation are rapidly disappearing upon regularly and efficiently operated air transport lines. Of the 5,272 trips scheduled, only four (less than 1/10 of 1 per cent) were not completed because of structural difficulties in the plane, and only 28 (or ½ of 1 per cent) were not completed because of mechanical difficulties with the engine. There were operated 2½ million miles with only three fatal accidents. Frankly, many of us can look back to the time, not so long ago, when our "pull-in" records were not as good as this, and we can, without hunting very hard, find some records now not as favorable. Many performance records are worthy of note. The Colorado Airways were scheduled to make 362 trips, and completed every one safely. Take the case of the Robertson Aircraft Company, which had 240 trips scheduled, and started out on every one of them, failing to complete but 9. This is a performance record of better than 96%. These 9 failures were attributed to the following causes: Weather 6, carburetor trouble 1, radiator trouble 1, and pre-ignition 1. On every trip, more than 50% of the distance was covered, the mechanical performance was 98.8 per cent, and there were no accidents. This is all the more interesting and impressive when we remember that a large percentage of these miles were flown in winter weather and at night.

We have been enthused by the trans-oceanic accomplishments and the bravery of those men has been brought forcibly to our attention. No praise too great can be given to Lindbergh for his solitary trip across the Atlantic. But also, great is the praise and commendation due those men who made a 100 per cent perfect start between Chicago and St. Louis (Lindbergh's training ground). Their schedule requires leaving Chicago at 5:50 in the morning, arriving in St. Louis at 9:15, and leaving St. Louis at 4:15 in the afternoon, arriving in Chicago at 7:30 at night. During the winter months, it is pretty dark at six in the morning and at 7:30 at night. These pilots came out to the field, and started out in their planes, on every scheduled trip for six months; always covered more than half the route, finished 96 per cent of the time (and during the other 4 per cent, were prevented from doing so mostly by weather), and had no accidents. It was this training that put Lindbergh across the ocean, and were he here today, I am sure he would agree with me that those men who start out on their scheduled time, day after day and night after night, regardless of what the weather man says, and regardless of their feelings at the time, are worthy of medals. They are transportation men and they go; and let's not forget them, when we are heaping well earned honors on the heroes of more sensational flights!

Little has been done in the matter of air express except upon the subsidized lines in Europe. The rates on these lines, because of their subsidy, are extremely low, very little higher than regular express rates; in fact, they are so low it is commercially feasible to ship fish and oysters by airplane express. In this country, if proper rates were charged, a lobster, shipped from Maine to St. Louis, would cost the hotel company more than $3.00 for the expressage, and I hesitate to estimate what the cost would be to the ultimate consumer, when served on the silver platter. In the first six months of this year, there were seven regularly operated air transport lines in the business of carrying express, and these lines carried a total of 1,035,000 pounds, which seems quite a good record. Our enthusiasm wanes, however, when we find that a million and ten thousand pounds originated on the lines operated by the Ford Motor Company, between Chicago, Cleveland and Detroit. This was not commercial express but spare parts, etc., for "flivvers," which the Ford Motor Company transmitted more as a test for its airplanes than for any commercial advantage in air transport.

The next largest carrier was the St. Louis-Chicago Line, which carried 21,651 pounds, principally flood relief material carried free. Obviously, these companies should rightfully be excluded from the calculation, leaving four, carrying a total of 2,768 pounds, the largest being the Detroit-Grand Rapids Line, which carried 2,404 pounds on 295 trips, or about eight pounds per trip.

It is plain to be seen we have yet a long way to go in air express, largely because we are not yet familiar enough with it. Few are the emergency shipments that can stand this rate, yet we believe they are sufficient to produce a sizable quantity of business, when the enterprise is thoroughly under way. Air matters move so rapidly, I am afraid much of the material here presented will be out of date. This is especially emphasized by the fact that, on the date I am writing, September 1st, the American Railway Express opens its air express service between New York and Chicago.

Passenger air transport is one of the most promising fields for development, but in the United States, has been neglected. Our passenger air transport is so small, we might as well say we have none. True, the joy ride, and so-called taxi business amounts to impressive figures, but as yet, there is no successful air transport line, operated with a serious view to carrying passenegrs. P. R. T. operations between Philadelphia and Norfolk lasted about five months. The Florida Airways, operating between Atlanta and Miami, suspended operations last December. The Stout air services, operating between Detroit and Grand Rapids, suspended operations this summer, after carrying a few more than 1,000 passengers in six months. They expect to reopen their service between Detroit and Cleveland. Five of the regularly operated air mail lines are carrying passengers, and for the first six months of 1927, these lines carried 768 passengers—about one a day—on each line. Such paltry passenger figures are hardly worthy of consideration, and do not truly reflect the public's desire to fly. They indicate that the passenger carrying business, in the main, is not being seriously conducted, and that, on the contrary, the companies generally are carrying merely those passengers that ask to be transported. Suitable accommodations, except on the New York-Boston and Detroit-Grand Rapids lines, are not provided. I have seen instances where passengers were permitted to sit on mail sacks, in open cock pits without protection, and even carried through mountainous country, on single engine planes, without a parachute, while the pilot, naturally, was adequately equipped. Such facilities cannot encourage passenger traffic; passenger transport lines should not be permitted to operate single engine planes. The public is ready, willing and anxious to fly, and will pay a good price for the privilege. This was fully demonstrated by our P. R. T. service between Philadelphia and Norfolk, operating during the entire five months at 50 per cent capacity, charging rates in excess of 10 cents a passenger mile.

Undoubtedly you will be interested in some statistics concerning this service, which was operated from July to December, in 1926. It originally operated between Philadelphia and Washington, and in September, was extended to Norfolk. There were used three Fokker tri-motor, 8-passenger planes, which flew a distance of 95,020 miles, without a single engine failure. The total flying time was 1,091 hours. During that time, there were 688 trips scheduled, and only 7 trips were not completed. In these latter cases, landings were made at a midway point, due to weather conditions. The service was operated 94% on time, and the majority of late trips were caused by heavy winds or weather. There were only 8 delays from any mechanical trouble, and no passengers were killed or injured.

Much is said of the danger of passenger operation. Danger and safety are always relative terms, and we need only go back to the press of 1845 to find such statements as, "the most formidable item in railway hazards is likely to be the list of killed." The British Air Transport service, during the last 7 years, flying 5,000,000 miles, have had only 4 accidents involving the death of passengers. In 1926, the companies composing the Lufthansa, in Germany, carried over 56,000 passengers, flying a total of more than 3,800,000 miles, with only one fatal accident. I have no hesitation in saying it is my firm belief that, if properly constituted and properly operating, air transport companies, equipped with multi-engine planes, can operate efficiently and regularly, with a safety record that will compare not unfavorably with that of railroads operating in the same territory. Air transport facilities are improving so rapidly, and have developed so successfully, that we should dismiss the danger element from our minds. During the five months the P. R. T. operated its triple-engine planes, it did not have a failure of even an engine on any flight. With proper inspection and proper maintenance, there is no reason why that record should not have been carried on indefinitely.

P. R. T. air service carried 3,245 passengers, paying the advertised rates. There was a period of from six to eighteen weeks during the summer when it was necessary to reserve seats weeks in advance. The fall and winter weather, however, reduced this demand so that, for the five months' period, we operated at an average of about 50% of capacity. Considering transportation in general, I think that is a very good average, and had it been possible to obtain a sufficient amount of mail and express business, I haven't a doubt that the operation would have been a pronounced financial success. However, our haul was much too short to expect any such volume, and therefore, this operation was instituted largely for the purpose of determining some real facts about aviation, which we did not seem to be able to get in any other way; and also, and this was not least in importance, to provide an interesting exhibit at the Sesquicentennial. Of all forms of transportation, and I have been connected with most of them, I find the airplane the most exacting and the most enjoyable. When you visit the airport, you can always get a big kick out of seeing your plane sail off with its passengers; and you can get a bigger kick when you see it coming in and landing safely. When the plane taxies up to the stand and discharges the passenger, they always step out smiling, and we came to the conclusion this was for one of two reasons: either they had had such a wonderful trip they were just in a glow of pleasure, or else they had been air-sick or scared to death and couldn't help smiling from relief when they got out. In either case it was a splendid advertisement.

Airplanes require the maximum of attention from a maintenance point of view. However, we found it possible to keep our ships ready for use more than 88% of the time. The life of those planes, before major overhauling and replacement, is expected to be 2,000 hours. The life of the Whirlwind motor that we used, I do not think has been definitely determined. We placed it, at the outset, at 500 hours, later moved it to 1,000, and I am inclined now to think 1,500 hours is nearer right. The Liberty motor must receive a thorough overhauling after each 100 hours. I should like to tell you what we found it necessary to do after 216 hours, or 21,000 miles, on our first set of Whirlwinds. Motor was partly disassembled, carbon removed, valves ground, push rods and intake plates enameled, engine cleaned and thoroughly inspected, oil strainers cleaned, magneto distributors cleaned, points cleaned on both magnetos, wires tested, and the motor reassembled. We found the following replacements necessary:

In engine No. 1—One ring in cylinder No. 3.

In engine No. 2—One ring and 1 exhaust valve in cylinder No. 7.

In engine No. 3—Five rings, 3 gaskets on intake manifold. 2 exhaust valves and 2 gaskets on oil pipe flange.

The total labor for overhauling the three engines amounted to 105 man-hours and just remember that that is an average of about 35 hours apiece on an engine that had been running in heavy service for 216 hours, covering a distance of almost 22,000 miles. It is the exceptional automobile engine that can show such a performance. However, many factors are responsible for it, one of which was that we held our cruising speed at 1,475 RPM and advanced to 1,600 RPM only at the time of takeoff. This gave us a reserve during the takeoff of 150 horsepower and a reserve en route of 354 horsepower. Also it was the result of very careful maintenance and inspection. Every day, 43 different items of inspection were covered on the engine. The plane itself was gone over and about 60 different items of inspection covered. All of this requires the most painstaking care and attention.

The matter of personnel is also vital. So much of the success depends solely upon the pilot. From the second he pushes his throttle forward to take off at the airport, until he lands at his destination, all of the lives and property are in his hands. First and foremost, he must be "a real he-man"; a good flyer, speaking technically; and a navigator; he must have good technical knowledge of his plane and of his engine, and judgment in the undertaking of flight. He must be something of a meteorologist, and most of all, he must have a thorough realization of his responsibility, with the ability to handle his passengers, to make a good representative of the company, and on the side, to be reasonably intelligent in the handling of the reports and forms required not only by the operator but also by the Post Office Department. At the outset of our operation, we made it the rule to employ no man as a pilot who had not had at least 500 hours experience in solo *cross-country* flying. I emphasize the words "cross-country" because there is as much difference between ordinary airdrome, stunt and military flying and flying for air transport as there is between city and country driving of automobiles; and in fact, much more.

Much of the difficulty, in establishing Passenger Air Transport at present, lies in the fact that our lines are organized and operated primarily for the carriage of mail, and with almost complete disregard of other factors. The contractor who will supply commodious triple-engine ships at a cost of $40,000 each, receives no more consideration than the one who will operate small single-engine ships of war-time design. Most of the mail moves at night, and few people are willing to fly at that time, although I assure you I have, on a clear night, found it most enjoyable and interesting.

Flying at night is no simple matter. The pilot sits in his ship on a brilliantly flood-lighted field, "gives her the gun," and takes off into the inky black space, where it seems absolutely nothing is visible. He takes up his compass course and starts out, leaving the brilliantly lighted field behind him. Shortly he will pick up the beacon lights, which have been installed by the Department of Commerce as an aid to aviation. These lights are land lighthouses, similiar to those placed along the coast for the guidance of mariners. In this instance, however, the beacons are of the searchlight type, being 24 inches in diameter, fitted with a parabolic mirror and a 1,000 watt projection type lamp, giving approximately two million candle power. The beacon is mounted on a steel tower, and revolves in a horizontal plane, showing the pilot 6 flashes per minute, on the horizon, to guide him on his course. In order to secure a dependable light, a lamp exchanger is installed which automatically swings a new lamp into focus, in case of lamp failure. These beacons are placed at intervals of about 10 miles, depending on the nature of the country to be served. In mountainous country, they might be on the top of each mountain ridge, and in level country, where normal visibility is fairly good, such as that west of Cleveland, they might be as much as 30 miles apart. December, 1926, saw 3,427 miles of airways lighted. By July of this year, 4,121 miles were lighted, and by July 1, of 1928, 7,512 miles will be lighted. So the Government is rapidly installing on land, facilities for air transportation comparable with those supplied on waterways for marine transportation.

The services of the weather bureau have been greatly improved within the last year or two so that now, in most of the large cities, it is possible to obtain complete weather reports giving not only the conditions at the point to which the aviator is destined, including wind velocity and visibility, but also showing the velocity and direction of the air currents at various elevations. Experiments are now going forward that will make possible many flights that must now be abandoned because of bad weather. For example: a plane on the transcontinental route may not leave Hadley Field in New Brunswick, when destined for Cleveland, because of the prevalent heavy fog in the Allegheny Mountains. With the radio beacon perfected, it would be possible to rise above the fog when encountered, if the pilot has the certain knowledge that there is good visibility at the Cleveland airport. A directive Radio Beacon was installed about July 1, 1927, on the New York-Boston and New York-Chicago routes at Hadley Field for a service tryout. It is planned to install additional radio beacon service, during the fiscal year of 1928, on 1,600 miles of airways, the beacons being located at 200 mile intervals, if proven entirely satisfactory. The beacon is nothing more nor less than a radio broadcasting station, or rather more properly, a "beamcasting" station, for it automatically transmits, in a beam converging at the station, a series of dashes—being the letter "T" in Morse. When off the course to the right, the sound becomes distinctly separated into a dash-dot, the letter "N," and when off the course to the left, it is heard as a dot-dash, or the letter "A." Preliminary experiments have shown this signal to be audible at a distance upwards of 150 miles, at which point the beam is but 8 miles wide. The Bureau of Standards is working on the problem of a small, low power, non-directive radio transmitting station, to be placed at intermediate points, say, every 30 miles, which will give a characteristic signal, that can be heard and recognized by the aviator, during a short interval when he is near or over it. As another radio aid to navigation, the Department of Commerce has been developing the radio 'phone for communication with the pilot in flight, planning sending stations at 200 mile intervals to give him those changes in weather conditions that have developed since he left his last port; and other information for the safety of navigation.

Of the essential characteristics of present day aircraft, those requiring improvement have been summarized by Major R. H. Mayo, representative of the Guggenheim Fund, as follows:

(1) The landing speed is far too high, and the length of run after landing is too great.

(2) The gliding angle is too flat, making the approach to a given spot or landing too difficult.

(3) The length of run required before taking off is too great.

(4) The angle of ascent after taking off is not great enough.

(5) If the airplane is stalled, it becomes unstable, and at the same time, control is lost.

The Guggenheim Fund has instituted a competition for the design of aircraft overcoming these objections, but even with the aircraft we have at present, manufactured within our own United States, there is no reason why passenger air service cannot be safely and efficiently operated.

Our manufacturers until very recently had given almost their entire attention to the development of military planes, and the military plane differs from the transport plane as vastly as navy ships differ from the merchant marine. However, there has now been quite a little interest and activity shown in commercial aircraft by all companies, but these have been principally in small single engine ships and it has remained for the Ford Stout Company to be the first American manufacturer to do intensive work in the development of a large commercial carrier.

Fokker has built a factory in the United States, and is turning out, regularly, his famous trimotor plane, which has such wonderful records of performance. Sikorsky also has turned out a few ships and it seems that, at no other time during the development of aviation, have there been so many different types of ships and has the development followed along so many different lines. The welded steel tube fuselage was developed by Fokker, and has been used generally by United States manufacturers. The United States has developed, until recently, mostly bi-planes with moderately thick wing sections, and England has developed bi-planes with thin wing sections. France has had wooden fuselages and wings of metal structure. We have metal fuselages and wooden wings. Germany builds monoplanes almost exclusively and uses duralumin almost entirely. France and England use duralumin very little, and our own country least.

The same diversity is true of engine design and recent developments have been most important because of the success of the air cooled engine. The U. S. Navy, realizing the value of the low weight and simplicity of the air cooled engine, has encouraged its development. As a result of the Navy's interest, the 200 H. P. Wright Whirlwind was developed, and has been most successfully used. The past year also saw the advent of the Pratt & Whitney Wasp, a 400 H. P. engine. Still larger types are the Pratt & Whitney Hornet, of 500 H. P., and the Wright Cyclone, of 525 H. P.

Another type of air-cooled engine, which is a redesigned Liberty, known as the Inverted "V," has been produced by the Army. It has been quite successful and is acclaimed by some engineers as destined to supersede the radial type, because of lower frontal area. On the other hand, some manufacturers, notably Curtis and Packard, have continued the development of water-cooled engines, as being the most satisfactory type, particularly for high-speed military planes. Curtis now has the "V" 1550, producing 600 H. P. at a weight of only 730 pounds. Packard has developed its 1-A and 2-A types, of 600 and 800 H. P., respectively. Both are 12 cylinder, "V" type engines. The air-cooled engine enthusiast points to lower weight and freedom from cooling system troubles, and claims equality of performance with the water-cooled type; obviously, these are most important advantages. Supporters of water-cooled engines admit the first two points but insist that, for high speed and high power, the water-cooled type is superior, and has greater reliability.

Unfortunate and laggard as our development in passenger service has been, other developments in the line of aerial service have outstripped anything known elsewhere. A very diversified and interesting industry has been built up in the use of airplanes and seaplanes. Aerial service is a collective term, including all forms of commercial flying, ranging from aerial taxi work to crop dusting, photography and survey by air, flying instruction, special aerial news service, and many others. The use of aircraft in these spheres has become almost indispensable as a saver of time and money, and as a more efficient method of carrying out certain essential services.

Four hundred and twenty operators reported owning 969 commercial planes in 1926. These operators and their machines are scattered throughout the entire country. The passengers carried were reported as 380,201. These must not be confused with air transport passengers, since a very large part of them were carried for rides of only a few minutes, in what is called "joy-hop" business. In addition to the passengers, 180,000 pounds of express matter was carried. The mileage reported for the year was 7,656,000. These statistics also include a certain amount of private flying, carried on by individual owners either for pleasure or personal business. The diversification of the uses to which airplanes are being put is really surprising. One of the outstanding events was the use of airplanes, by newspaper men and photographers, at the time of the explosion at the Naval Arsenal at Dover, N. J. Another event was following the death of Colonel Coolidge, when photographs, brought from Vermont by air, were the only ones to arrive in time for use in the daily newspapers. A rush shipment of Golflex clothes was carried from New York to Florida. Three planeloads of Goodrich Zipper overshoes were flown to New York, when the February blizzards tied up all transportation. A Florida Airways plane rushed one-half million dollars in gold to Miami bankers, from Jacksonville, in the emergency following the hurricane. Food and supplies were at various times carried by airplane to people on an icebound fishing tug on Lake Michigan. Airplanes were used to feed the birds on the snow-clad mountains of Pennsylvania, for sowing rice in marshlands of Manitoba, for surveying teakwood in the Philippines, for the patrol of uncharted seas in British Columbia, for scouting for whales and schools of fish, and for transporting payrolls to Mexican mining camps. Crop dusting is a business in itself. The Huff-Daland Dusters, the largest commercial company specializing in this work and using special type of dusting airplanes, have dusted no less than 124,000 acres of cotton in the southern states to protect it from the boll weevil.

We might go on indefinitely with special examples of such uses for aircraft, but I have confined my remarks principally to the subject of air transport lines, which to my mind is the most important application and the one most difficult of accomplishment, because of the large amount of capital involved, the heavy risks, and the difficulty of letting go of the proposition when it is once established. With the risk of verging on carping criticism. I feel constrained again to utter a word of caution. At present we are in the midst of a great wave of enthusiasm for all things aeronautic. It is an actual fact that many investors are searching for aeronautical ventures in which to embark. It is also a certain fact that some aeronautical enterprises are being foisted upon the public on a wildcat basis. It is feared that harm to the cause of aviation will result. This newest of transportation enterprises stands unprotected and is struggling along almost unassisted. True, the Government is spending large sums on weather reports and in lighting and marking airways, but this is no more than has been done for marine transportation and can be considered no more of an assistance. That which to my mind is now most vitally needed is regulation. It seems almost paradoxical to recommend regulation of an infant industry in order to help it. However, I believe that intelligent regulation would prove to be the best friend the aeronautical industry could find.

For 75 years have we been struggling with our railroads on a competitive basis and now are taking active steps to remedy that evil, not only through mergers but also by the transportation act. With this experience as a guide, there is every reason to develope this newest transportation agency upon the principles found to be just, right and economically sound, rather than to permit haphazard growth, troublesome to correct at some later date. This new industry should have the full benefit of all our railroad experience has taught us.

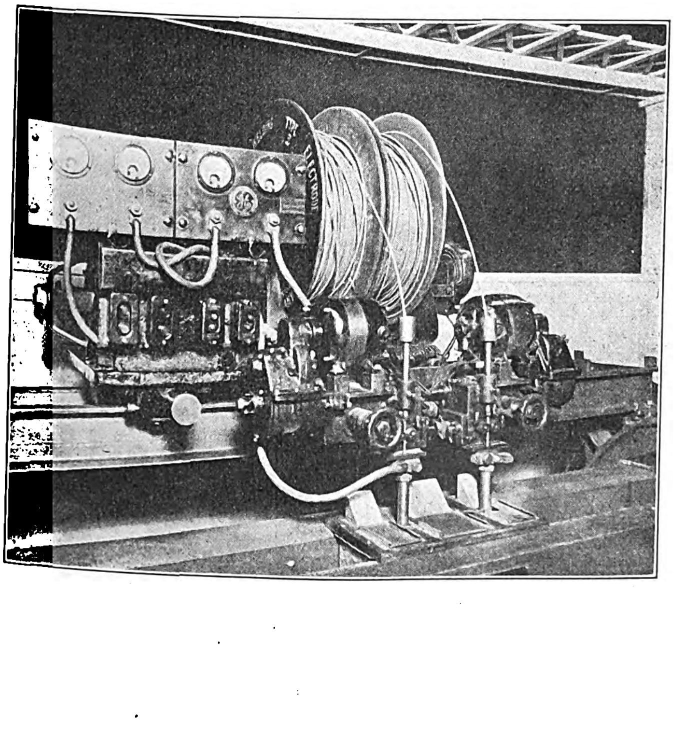
Few of our air mail lines are prospering. After competitive bidding, a contract for a period of four years is received. It is within the range of possibility that each of these lines, within the four year period, may bring its earnings up to a point where it is a profitable venture. Then again, they must face the hazard of bidding for their mail contract, in order to stay in business, and beyond the shadow of a doubt, if their line proves to be profitable, they will have to cut their price to a point where little or no profit remains, or some rival company will take it away from them. Such changes in operators should be most unsatisfactory to the Government. How much better would it be if one member were added to the Interstate Commerce Commission, to be known as the Commissioner of Aeronautics; if no air transport line could be established, without a certificate of convenience and necessity; if no air transport line could be established, without proper financial responsibility, and without placing a proper service at the disposal of the public! With this arranged, the Post Office Department could then reward this carrier with the privilege of carrying the mails on a proper basis, which would give recognition to the standby element in the service and to the difference in costs arising from service over long and short routes. I very much fear the present operators are going to spend their first four years developing a business only to lose it, or to have their compensation reduced to such a point that they must spend another four years with little or no profit.

I have tried to give you a view of the principal features of this most fascinating subject of air transportation, and some idea of the direction in which it is moving. I want to close my remarks with an appeal for your support for the advancement of aeronautics. Air transportation is merely important to our Country, in time of peace; but in times of war it is vital. Through the advance of commercial aviation, are we going to bring up a large number of our young men to be air-wise and air-minded, so that at the beginning of the next war, we shall not be almost destitute of talent or facilities for producing the proper material. Now I am going to suggest tangible and definite means by which this Association, as a body, and its members, individually, may do a comparatively small thing, but one which, if carried out as a whole, will be a major benefit and, I believe, not wholly unproductive of satisfactory results to yourselves.

If you will pardon a personal reminiscence, about a year ago, when flying from Atlanta to Nashville, we became confused in the number of mountain ridges we had passed over. We flew around and found a town; we looked it over, but there were no land-marks to check up on the map to identify it, so our only recourse was to go down very low, and fly by the end of the railroad station to read the sign there. All of this involved quite a little maneuvering and you may imagine my astonishment when, the next day, I read in the Nashville paper headlines, "Did the Airplane Spy Out the Land"—"Airplane Flew Low Over Tracy City Yesterday Afternoon and the Bank Was Robbed Last Night." So, to help the aviators know where they are and keep them from being misjudged, as I was, I am going to make the suggestion that this Association pass a resolution recommending to its members that they immediately take steps to mark on the roofs of their carhouses, or at least of one carhouse in the city they serve, the name of that city with an arrow pointing toward its airport. The manner in which this can be done is described in Information Bulletin No. 38, issued by the Aeronautical Division of the Department of Commerce. I feel it would be of no small help to the electric railway industry for the news to be generally spread among the air people that, when you're lost, you'll find assistance on the roof of the street railway carhouse. With just a thought toward the future, save a little space on that roof, because if air transportation grows, as I hope it will and believe it will, you will be able to sell that space for advertising purposes, and space adjacent to what has always been known as a land-mark, will be the more valuable.

Higher Welding Speeds Possible with New Welder

Welding heavy plates automatically at approximately ten times the speed which can be obtained with the single-arc manually controlled process, is now possible with a new automatic arc welder. The new machine, shown in the picture, bears the designation Duo-Arc Automatic Welder and consists of a standard travel carriage on which are mounted two automatic welding heads, and two reels of electrode wire. With this equipment the operation is just as simple as that of the single arc travel carriage. One attendant can supervise the two welding arcs as easily as he can one arc.



The new welder is of particular value in butt welding heavy plates. This is accomplished by two electrodes working one behind the other simultaneously. Thus the necessarily large quantity of metal required to fill up the seam is deposited in practically one-half the amount of time which would be required for the travel of one electrode.

The ordinary method of depositing the required thickness of metal in welding heavy plates is to weld twice with a single electrode over the same seam.

By using two electrodes, welding simultaneously, the time required to repeat the welding with a single electrode is saved.

An electrode larger than ¼-inch in diameter is not commonly used for high grade work because the deposition of metal cannot be accurately controlled and it is inconvenient for operators to handle the large amounts of electrical energy necessary, concentrated in a single arc.

For welding half-inch plate, the seam is prepared by beveling to an angle of 30°, total opening. With 3/16-inch electrode and approximately 250 to 300 amperes in each arc, a speed of welding of from five to seven inches per minute may be obtained. Thus the speed of welding is approximately ten times that obtained with a single arc manually controlled and the resulting weld is of better quality because of the decreased chance of burning the weld.

The Business Situation

DURING the last few weeks of each year many minds contemplate the work and opportunities of the past year in the hope that past experience will enable them to prophesy developments during the coming twelve months. No economist has been more successful in prophesying as to coming business conditions than Colonel Leonard P. Ayers, Vice-President of the Cleveland Trust Company, who this year takes quite an optimistic view of 1928 probabilities. We quote the following from his advance release:

"It might well be argued that it is somewhat illogical to discuss business in terms of years, for trade, and industry, and transportation are continuous activities which do not halt when one year has drawn to a close, and recommence when another year begins. The calendar year is not the most significant unit of measurement by which to gauge the ebb and flow of the business tide.

There is an irregular, but ever active, tide-like fluctuation of general business which, in this country for a century back, has been carrying industrial and commercial activity each few years from the low ebb of depression up to the full flood of prosperity and back again. Our discussions of past and prospective business would be more illuminating if they could be formulated in terms of these irregular and irregularly spaced waves of business activity, than they are now when they are in terms of calendar years.

If our understanding of business were sufficiently adequate to make such a thing possible it would be logical for us to discuss business in terms of cycles. Probably it would be particularly appropriate to do so at this time, for it appears likely that we are now in the closing phases of the business cycle that began in the summer of 1924. That probability appears to be the most important fact about general business at the present time.

Three Cycles Since War

"Since the war there have been three great irregular waves of business activity. The first began early in 1919 in the brief period of depressed business that followed the armistice. This was the Post-War Inflation Cycle that lasted through the stimulated prosperity of 1919 and 1920, and ended in the great depression of 1921. Then came the Recovery Cycle, which began in the summer of 1921, carried on through the brief prosperity period of 1923, and came to an end in the mild depression of 1924. Following that there came this present cycle, sometimes called the Coolidge Prosperity Cycle, which began in the summer of 1924, reached its high points of prosperity late in 1926 and early in 1927, and has been gradually receding during the past seven months or so.

Ever since last spring general business activity has been declining, not very rapidly, but pretty steadily. It is now below normal in a number of industries. Shortages are in the making in such fundamental lines as iron and steel output, the manufacturing of automobiles, and the production of railroad equipment. There are no important stocks of goods in storage to supply the needs for these products, and yet the current rates of manufacturing are below those necessary to meet the normal requirements of the country. Since this is true, and since production is still slowing down, two forecasts seem justified. The first is that the worst is yet to come; the second is that things will be better soon.

A New Business Era

We are in a new era of business that is characterized by stability but only relative stability of industrial activity, of credit rates, and of commodity prices. The credit stringency that formerly came in business cycle is still with us, but it no longer runs through the old wide swings from profound depression to feverish prosperity, and back again. Its irregularities have been in large measure smoothed out. Its peaks have been partly taken off, and its valleys largely filled in. We need no longer fear the severe times of unusual business activity, and since our credit supplies are now ample, and are skilfully and flexibly administered through the Federal Reserve System, the movements of security prices no longer bear the same relationships to the business cycle that they did formerly.

We are now in the closing phases of the first of the business cycles of this new type. We have had a long period of prosperity which has finally given way to a slow decline that has already reached mild depression levels in some lines. Production has fallen off, commodity prices have declined, profit margins have narrowed, and insolvencies have increased. Meanwhile, bond prices have advanced, and there has been a long bull market for stocks.

The persistence and strength of the long upward movement of stock and bond prices do not fit in well with the evidence indicating that we are now in the closing phases of a business cycle. In the past the movements of bull and bear markets for securities have almost always been in fairly close accord with the upward and downward movements of general business, and usually somewhat in the lead. This time we have a persistent sagging off in business accompanied by an unusually long and strong bull market for stocks and bonds.

The explanation is to be found in our great credit supply, which is now so very ample that we have been able within the past few years to finance simultaneously a building boom, a business boom, a Florida boom, and a stock market boom without bringing about anything of a credit stringency. In former years, when our credit system lacked flexibility, a period of exceptionally active business always operated to stiffen up money rates sufficiently to turn security prices downward, and contrariwise a period of depressed business regularly resulted in such an ease of interest rates as to start security prices moving up again. Because these movements recurred again and again the belief became general that the movements of stock prices forecasted the movements of business. The fact is that they do when credit supplies are restricted, but they are very poor business forecasters when credit resources are ample.

Four Essentials for Recovery

The present prospects are that the conditions of general business will improve in the not far distant future. There seem to be four conditions that are necessary for business recovery following a depression. The first of these is expanding industrial production. It seems reasonable to expect this early next year, because the normal consumption of a number of essential industrial products calls for greater rates of output than those now being recorded. Since there are not many over-sized inventories to be worked off, production must soon increase or consumption decline, and this country is fundamentally too healthy in a business way to permit of much reduction in its accustomed rates of consumption.

The second essential for business recovery is an ample supply of easily available credit, and that we have, and apparently shall continue to have. The third requisite is agricultural well-being, which we have at least to a degree entirely greater than seemed at all possible only a few months ago. The buying power of the agricultural districts this winter and next spring will be better than it has been for several years past.

The last of these four essentials is a good export trade, which seems assured for at least most of the coming year. Our export trade has been of large proportions this year, and the domestic and world trade of other countries of this continent and across the seas is now increasing at a pace that makes it seem probable that they will benefit us more by being better customers in 1928 than they will hinder us by being keener competitors. We may sum up the situation by noting that all four of the requisites for sustained business recovery promise to be active and effective in 1928.

Items of Interest

Research Is Not Mysterious

"During somewhat more than fifteen years' contact with both 'pure' and 'commercial' research work I have observed a general belief that research is something mysterious and uncanny," writes W. S. James, research engineer of the Studebaker Corporation, in The Journal of The Society of Automotive Engineers for September. "This belief has been fostered rather than corrected by the popular magazine and newspaper versions of scientific research. At present I feel that the word 'research' is losing its true meaning, and research endeavor, valuable as it is, may suffer from this misunderstanding.

"It should be easy to see why anyone working in research should have a well developed, natural and honest curiosity, and should be able to tap unusual sources of information and to perform experiments to check suggested solutions. Problems which require immediate solution are common in any industry today. The quickest solutions of such problems are obtained when they are attacked by someone with an honest, inquiring mind who has access to all available information. When essential information is lacking it is impossible to check experimentally with ideal accuracy, but a more nearly correct answer can be obtained with common sense and attention to facts previously established.

"In the automotive industry it has often been said that no time is available for the solution of any but immediate problems. It also seems that few men in the industry are considering seriously what problems will confront them one year or five years ahead. At our present stage of industrial development very few facilities have been co-ordinated with industrial activity for carrying out work of this nature.

"University laboratories and similar institutions are the most promising sources for the solution of such problems, but their contact with industry is usually limited and their knowledge of future problems of industry is, therefore, lamentably weak. Were it possible to arrange a scheme of co-operation between industry and such institutions for working out problems of general or potential industrial interest, a two-fold benefit would result, as industry would be provided with information at an opportune time and the men leaving the universities would have a clearer understanding of the problems of industry through the closer contact of their professors with industrial problems.

"One of the possible by-products of such a relationship would be the retention in this particular line of endeavor of the men who are best fitted for it. Some men show marked aptitude for research work. Such of these men as are outstanding should be so fitted into our economic structure as to utilize their abilities to the maximum. If they could work with commercial objectives in the university atmosphere, much good would result."

New York Edison Company to Have World's Largest Electric Generator

An electric generator rated at 160,000 kilowatts is to be installed by the New York Edison Company in its generating station at 14th street and East River. The generator will have a capacity nearly three times as large as any in service, and more than half again as large as any under construction anywhere in the world.

The generator will be driven by a tandem-compound steam turbine, which means that all of the equipment will be mounted on a continuous shaft. Included will be a single-flow high-pressure turbine element, a double-flow low-pressure turbine element, the electric generator, and a direct-connected exciter. The tandem-compound turbine differs from the cross-compound turbine in which the different turbine elements drive separate electric generators.

The new generator will be rated 160,000 kilowatts at 1.00 power factor, 1500 r.p.m., 3 phase, 25 cycles and 11,400 volts. The turbine will receive steam at a pressure of 400 pounds and a temperature of 700 degrees Fahrenheit, and will exhaust at one inch absolute pressure. The entire set will be 82 feet, 7 inches long, and will weigh 2,228,000 pounds—well over a thousand tons. Installation of the equipment will be completed by October 1, 1928.

American Engineers Participate in a Five Hundredth Anniversary in Europe

Engineering Foundation was invited last spring, as the joint scientific organization of the American Societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers, to assist in celebrating the fifth centenary of the University of Louvain, Belgium, on June 28 and 29. The Foundation accepted on behalf of its Founder Societies, and designated as its delegate its Honorary Member, Doctor Edward Dean Adams, John Fritz Medallist, 1926, widely known as the leader in the development of hydro-electric power at Niagara Falls. He was likewise delegated by the Societies individually and Engineering Societies Library. Doctor Adams, having spent the summer abroad, has just reported on his mission to the fall meeting of Engineering Foundation Board, held October 20th.

On June 28th, in the great hall of the ancient university, before a distinguished assembly attended by the King, the Queen, the Crown Prince, dignitaries of Church and State, and representatives of universities and national academies from many countries, he presented to Louvain University, from the six bodies he represented, formal congratulations bound together in a beautiful book, thus typifying united action by the individual national societies. The unique form of the missive and the fact that Doctor Adams represented 56,000 American engineers, made a deep impression upon our Belgian friends and those from other countries. They were keenly interested in this achievement of permanent joint means for a variety of purposes by four great technical societies, while maintaining vigorous individual existence and carrying on independently activities in their several fields. The fact unquestionably reflected great credit upon these societies.

Doctor Adams introduced another unique feature into the celebration, the giving and planting of four seedlings of Sequoia Gigantea as memorials of the participation of the four American Engineering Societies in the fifth centenary of Louvain University. These four little California Redwoods were planted by Doctor Adams and his grandson, Kempton Adams, in front of the new engineering building and will be known as the Engineering Sequoias. They should thrive in the climate of Belgium, attaining great height and for centuries keeping green the thought of friendly cooperation between engineers of America and Belgium.

In presenting the trees before a large group of notable personages, Doctor Adams said:

"These four little trees of the Sequoia Gigantea, popularly known as the Giant California Redwood, have been brought from the mountains of the Pacific Coast across the American Continent to the State of New Jersey, where they were propagated, and have now completed their journey across the Atlantic Ocean, and have been planted in the soil of Louvain. You have seen scattered among the roots Belgian oats, the warmth of whose germination will encourage and stimulate the growth of these little trees.

"Let each of the Sequoias represent one of the four great national engineering societies of America. They are contributed to the five hundredth anniversary of the founding of the University of Louvain, with the expectation that they will prosper in friendly soil and, by their natural growth in height, strength, and beauty, represent the development of the University during the next five hundred years."

The trees were accepted and the response to the American delegate's sentiments was made by Professor Albert van Hecke, Dean of the Engineering Schools of Louvain University.

Doctor Adams with others had an audience with King Albert, and on several occasions he personally met Queen Elizabeth. Everywhere he was received with great honor. At all times he endeavored to impress those whom he met with the desire of the great body of American engineers to establish cordial relations with engineering societies of foreign countries for the maintenance of peace and the advancement of civilization. As a token of friendly esteem for Engineering Foundation and its constituent societies, the University of Louvain conferred upon the Director of Engineering Foundation the honorary degree of Doctor of Applied Science.

Established in 1427, the Catholic University of Louvain has been a leader in the advancement of learning. It was one of the first European universities to give attention to the natural sciences. Its college of engineering and science grew and did excellent work until severely injured, along with other parts of the University, by the German invasion of 1914. Its great library was totally destroyed by fire. The University is being restored and enlarged with the aid of friends in Belgium, the United States of America and other countries.

The new library building, of fireproof construction, is nearly finished and has been characterized as one of the most beautiful buildings in Europe. Shelving and other equipment for library service are being provided. It will be a complete gift from Americans to the Belgians, in appreciation of national fortitude and of contributions to the advancement of learning and the progress of civilization.

Two items, however, are lacking, for which provision should be made before the dedication next spring or summer. In the tower of the building are places for a four-dial clock, striking the hours and quarters, and for a carillon. To a people whose bells for many generations have been famous for their sweet music, there could be no more acceptable reminders of American good-will. Here is an opportunity for American engineers to have a definite part in cementing the friendly, enduring bonds and to give expression to their highest sentiments. As the Engineering Sequoias raise their evergreen crowns slowly skyward, the clock bells would chime the hours of continuing cooperation and the carillon would play "America" with the anthems and carols of "les Pays Bas." What nobler applications could be made of "the art of directing the great sources of power in Nature for the use and convenience of man," the definition of engineering by Thomas Telford written into the constitution of the Institution of Civil Engineers of Great Britain?

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The Engineers Club of Philadelphia, as a body, is not responsible for the statements and opinions advanced in this publication.

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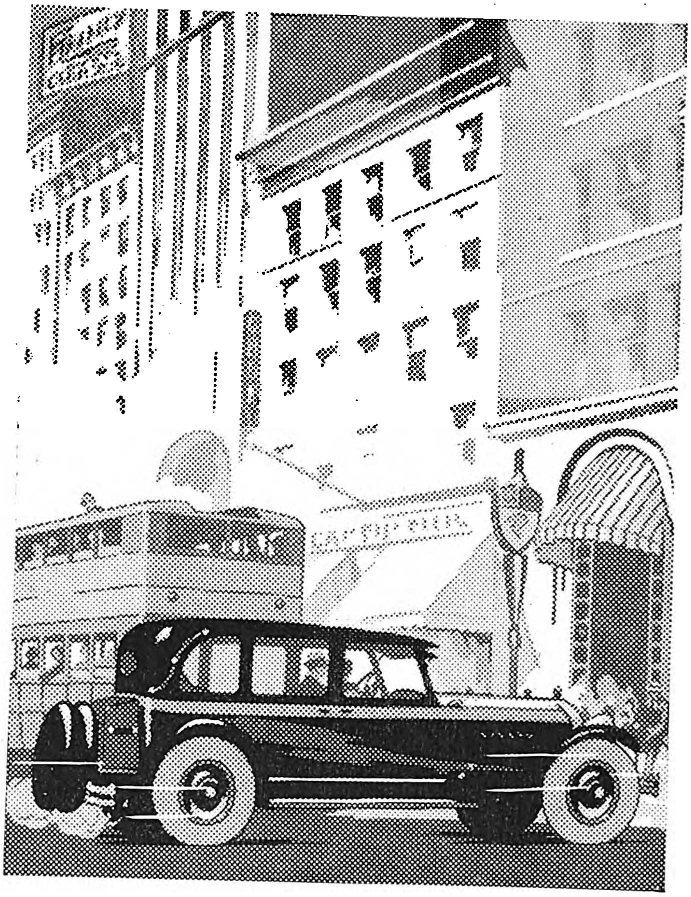

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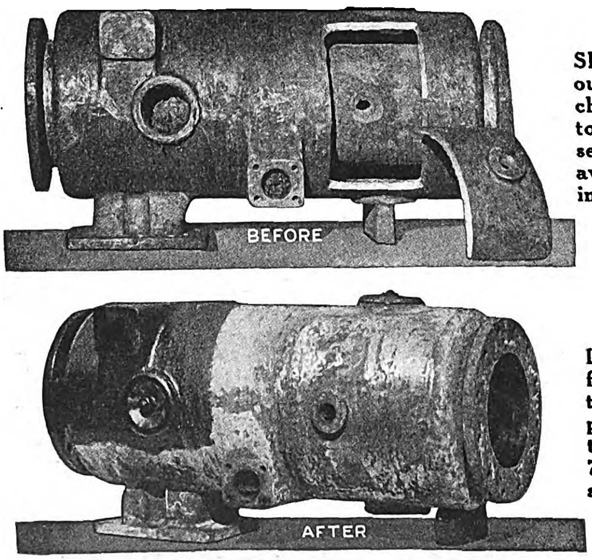

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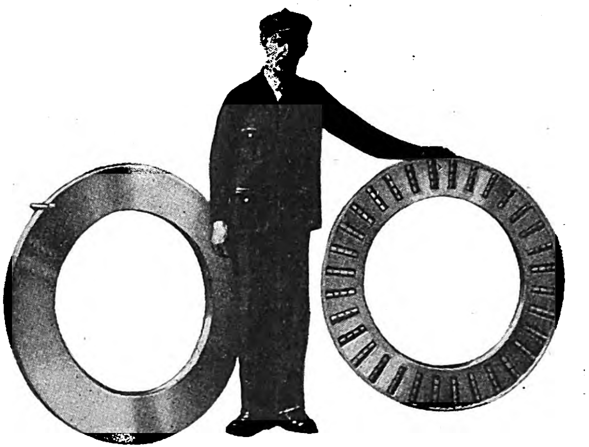

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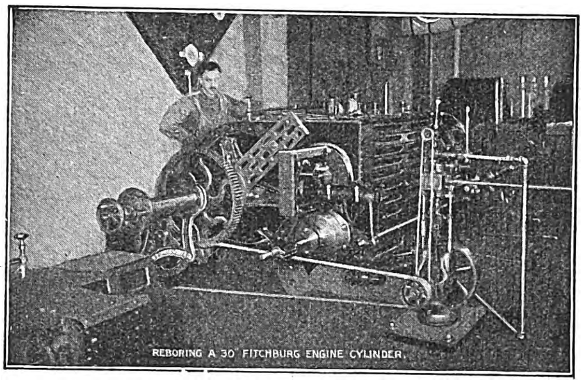

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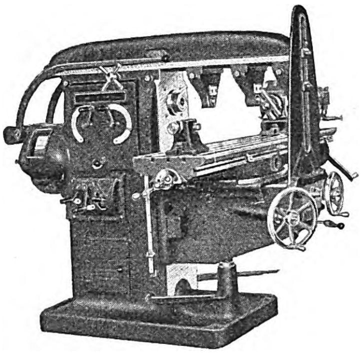

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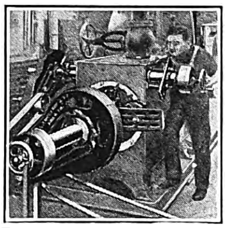

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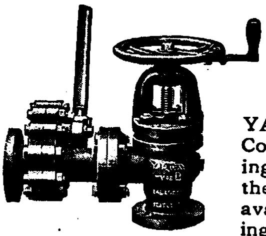

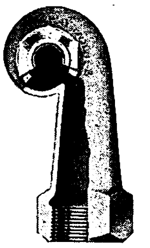

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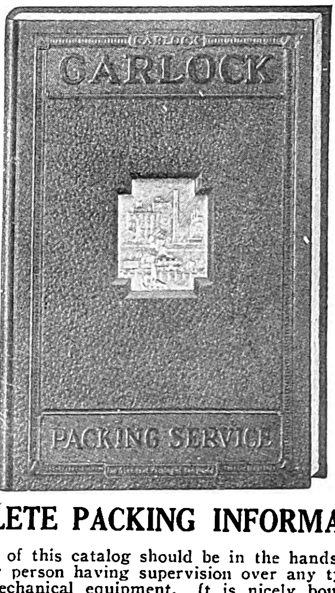

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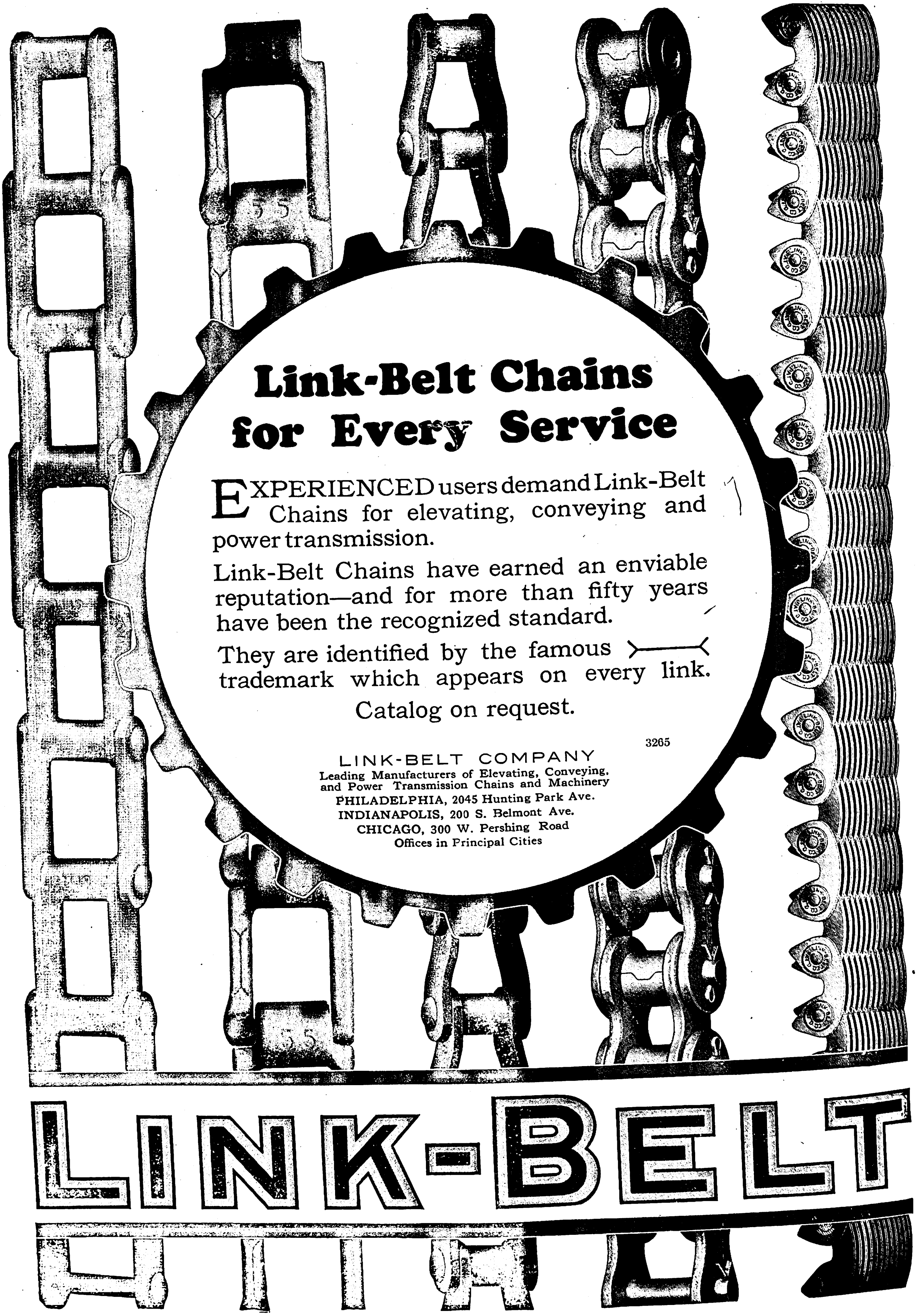

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